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SPRINGFIELD ARMORY

SPRINGFIELD, MASSACHUSETTS

RESEARCH AND DEVELOPMENT

Report: SA-TR19-1506

Date: 7 November 1961

Report Title: Properties and Methods of Nondestructive Testing of Receivers for 7.62mm M14

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for H. F. HAWTHORNE
Chief, Res and Dev Div

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RESEARCH AND DEVELOPMENT DIVISION

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REPORT SA-TR [illegible]
November 196[illegible]

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ABSTRACT

Studies were made to develop a nondestructive test for the segregating of receivers made from materials other than the specified resulphurized 3620H steel, and to determine the feasibility of using the electromagnetic test for this segregation. The electromagnetic comparison test gave 100 per cent correlation with spectrographic analysis results of 554 receivers. The developed method did not correlate completely with core properties in the receiver lug areas. The results obtained by this method are influenced by variations in the heat-treat procedures. It was recommended that the electromagnetic method be used in conjunction with core hardness predictions by Rockwell C and D measurements at designated locations. Test procedures are described.

CONTENTS

CONTENTS - Continued

TABLES AND ILLUSTRATIONS

TABLES AND ILLUSTRATIONS - Continued

TABLES AND ILLUSTRATIONS - Continued

REPORT
SA-TR19-1506

SUBJECT

Nondestructive Test Investigations of 7.62mm M14 Receivers

AUTHORITY

Minutes of M14 Rifle Conference at Headquarters, Ordnance Weapons Command, Rock Island, Illinois on 22-33 March 1961

PURPOSE

The purpose of the investigations was twofold: to develop a nondestructive test method to segregate receivers made from materials other than the specified 8620H resulphurized steel, and to determine the feasibility of applying the developed electromagnetic test method used in segregation and other test methods for final and in-process inspection of receivers to control quality.

SCOPE

The report summarizes the following investigations conducted by Research and Materials Laboratories, Springfield Armory:

1. Nondestructive Material Segregation Studies
    a. Examination of Fractured Receivers
    b. Initial Screening Studies
    c. Test Development Studies
    d. Correlation Studies
    e. Segregation Program
2. Nondestructive In-Process Inspection Studies
    a. Distribution Studies of Magnetic Comparator Readings
    b. Third Harmonic Studies
    c. Mechanical Hardness Tests for Core Hardness Evaluation

CONCLUSIONS

1. Electromagnetic comparison type test method was successfully developed to segregate receivers manufactured from improper steels. The method provided 100% correlation with spectrographic analysis results on 554 receivers. This method was applied to the inspection of approximately 36,000 receivers at Raritan Arsenal and at contractor plants. A total of 35 receivers of spurious material was segregated.

CONCLUSIONS - Continued

2. The developed method used in receiver segregation did not completely correlate with core properties in the receiver lug area required for in-process inspection of components. This method was influenced by variations in heat-treat practices and procedures used by different contractors. Occasional heat lots of individual manufacturers appeared to offer direct correlation, but when combined with other heat lots from the same manufacturer and with heat lots of other manufacturers, only a partial correlation was found to exist. Prior forging procedures and techniques are believed to have greatly influenced magnetic test results on receivers similarly treated.

3. The magnetic method used was not 100% reliable in determining the actual core hardness properties in any specified area, e.g., the lug section. The instrument averages the conditions prevalent in the material which is within the field of the coil. The component has varying section sizes, thereby producing variations in core hardness between different sections. Inherent process variations of different hardenability steel, quenching speeds, tempering cycles, and variables such as residual magnetism are further deterring factors to direct correlation.

4. Although the magnetic comparator did not offer direct correlation, the contractors' use was most beneficial. The method showed when variables had been introduced in processing individual heats; this made correction of conditions possible before large numbers were manufactured. As contractors' techniques and procedures became more uniform, process was more systemized with resultant controlled product quality.

5. Third harmonic studies did not completely correlate with component material properties. Use of the ratio of magnetic comparator reading to third harmonic amplitude showed somewhat improved correlation in that it was possible to differentiate receivers which had been highly tempered or retempered from generally low core hardness, such receivers had greatly influenced both magnetic comparator readings and third harmonic amplitude when studied separately .

6. Test method employing a combination of Rockwell D and C hardness measurements in designated receiver locations was developed. Predictions made offered excellent correlation with core hardness. Core hardness estimates were predicted on a total of 170 production receivers which were destructively examined: 93.5% of the estimates were correct to within 2 points Rockwell C; 99% were correct to within 3 points Rockwell C. Method also applied to receivers from other contractors.

CONCLUSIONS - Continued

7. An investigation should be made to improve the reliability of the magnetic permeability test by using core hardness predictions. ~~Studies might result in correction of zero position for each heat lot of components.~~

RECOMMENDATIONS

1. Because of benefits derived in proper use of the electromagnetic method by manufacturers, it is recommended that the method be continued in use in contractor plants in conjunction with core hardness predictions by Rockwell C and D measurements at designated locations. Each contractor should endeavor to use the tests to best advantage - that of indicating when variables have been introduced into process and to further improve manufacturing procedures. In order that this end be accomplished heat lots should be maintained separately, and appropriate measures taken in heat-treat practice to produce desired properties. Means should not be sought by contractors to devise methods of defeating test purpose. Tests have not been introduced to cause hardships or material rejection, but to assure component quality.

2. It is recommended that Research and Material Laboratory, Springfield Armory, study the effect of different forging procedures to determine whether any particular controls should be placed on processes to reduce variables in heat-treat.

3. It is recommended that Research and Materials Laboratory continue study of materials, heat-treatments, and nondestructive tests to evaluate properties and service life of components.

INTRODUCTION

The program to develop a nondestructive test method to segregate M14 receivers (component drawing F 7790189) manufactured from improper steel began in December 1960 because of castastrophic failures in weapons at Ft. Benning and at "Code HG" plant. Chemical and metallurgical investigations of fractured receivers revealed fabrication from 1330 steel, with resultant core structures hard and extremely brittle. Specification required fabrication from 8620H resulphurized steel. Nondestructive test studies resulted in the development of an electromagnetic test method. The segregation program was subsequently undertaken on all manufactured receivers at contractor plants and on all suspect weapons impounded at Raritan Arsenal.

INTRODUCTION - Continued

During segregation investigations, it was observed that components manufactured from 8620H steel developed a variety of structures and properties. Many variations in heat-treat methods and procedures at contractor plants were found. Greater in-process control was deemed necessary. Examinations of failed M14 and M1 receivers, were reviewed together with destructive tests of current production in order to establish optimum conditions for the core in the lug section of the receiver. In addition, studies were undertaken in the development of a nondestructive test means of evaluating quality. Studies were made with components produced by all contractors.

NOTES:

1.

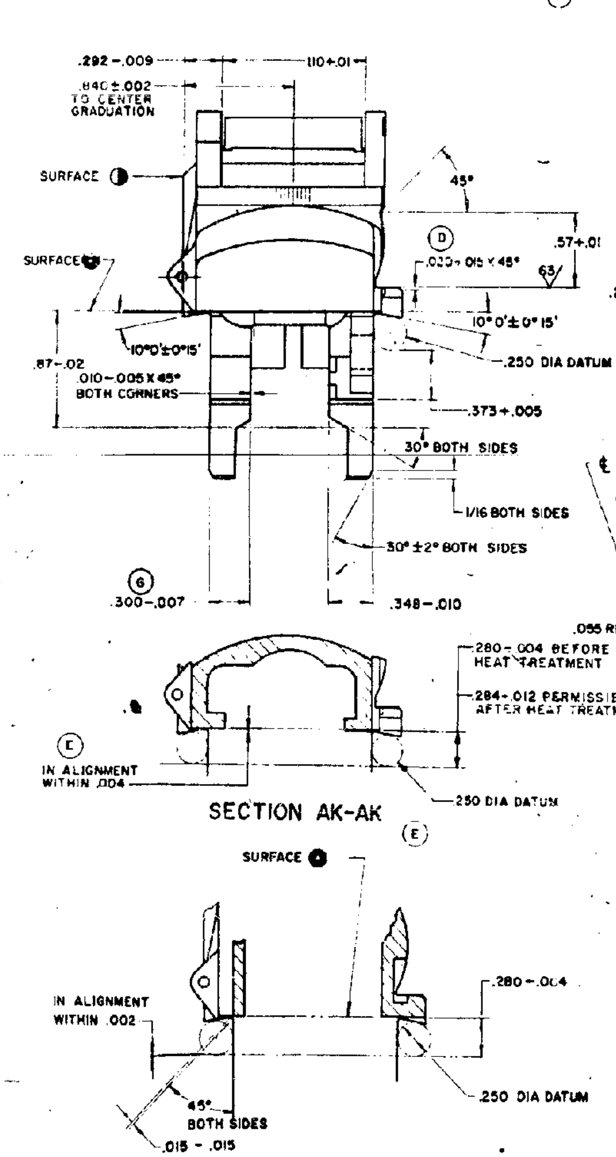
2 FINISH 125 EXCEPT AS NOTED.

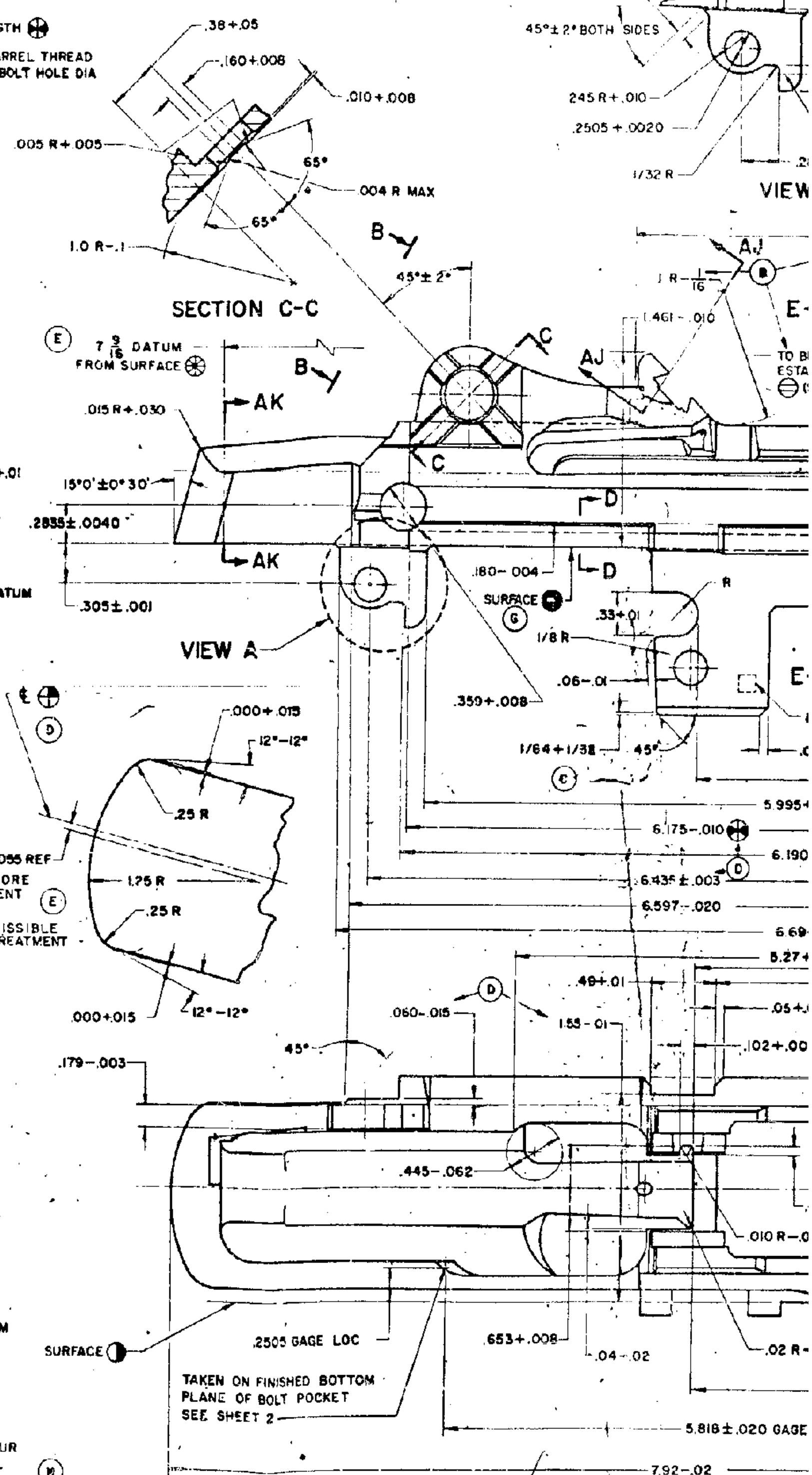
3 MATERIAL: STEEL, FED SPEC QQ-S-624; 8620H, EXCEPT RESULPHURIZED (SULPHUR .035 TO .055%) GUN QUALITY. GRAIN SIZE AS DETERMINED BY ANY ONE OF THE FOLLOWING PROCEDURES FROM FED TEST METHOD STD NO. 151, METHOD 311.1:
a. 5 OR FINER, PROCEDURE A
b. 6 OR FINER, PROCEDURE C
c. 7 OR FINER, PROCEDURE F, AS QUENCHED FROM 1575°F±-°F SPECIMEN DIA OF 3/8 IN PERMITTED
THE QUALITY AND CLEANLINESS OF THE STEEL SHALL BE EQUAL TO OR BETTER THAN MACROGRAPHS A5-B4 CONTAINED IN MIL-M-12286 WITH ALL D DEFECTS UNACCEPTABLE.

5 UNLESS OTHERWISE SPECIFIED:
a. ALL EXPOSED EXTERIOR EDGES AND CORNERS SHALL BE BROKEN .015+.015;
b. ALL INTERIOR CORNERS SHALL BE ROUNDED WITH A FILLET OF .005 R+.010;
c. ALL OTHER EDGES AND CORNERS SHALL BE BROKEN .005+.010.

6 DIM APPLIES TO LENGTH

7. ℄ ESTABLISHED BY BARREL THREAD MINOR DIA .918+.004 AND BOLT HOLE DIA .730+.005 AT BRIDGE.

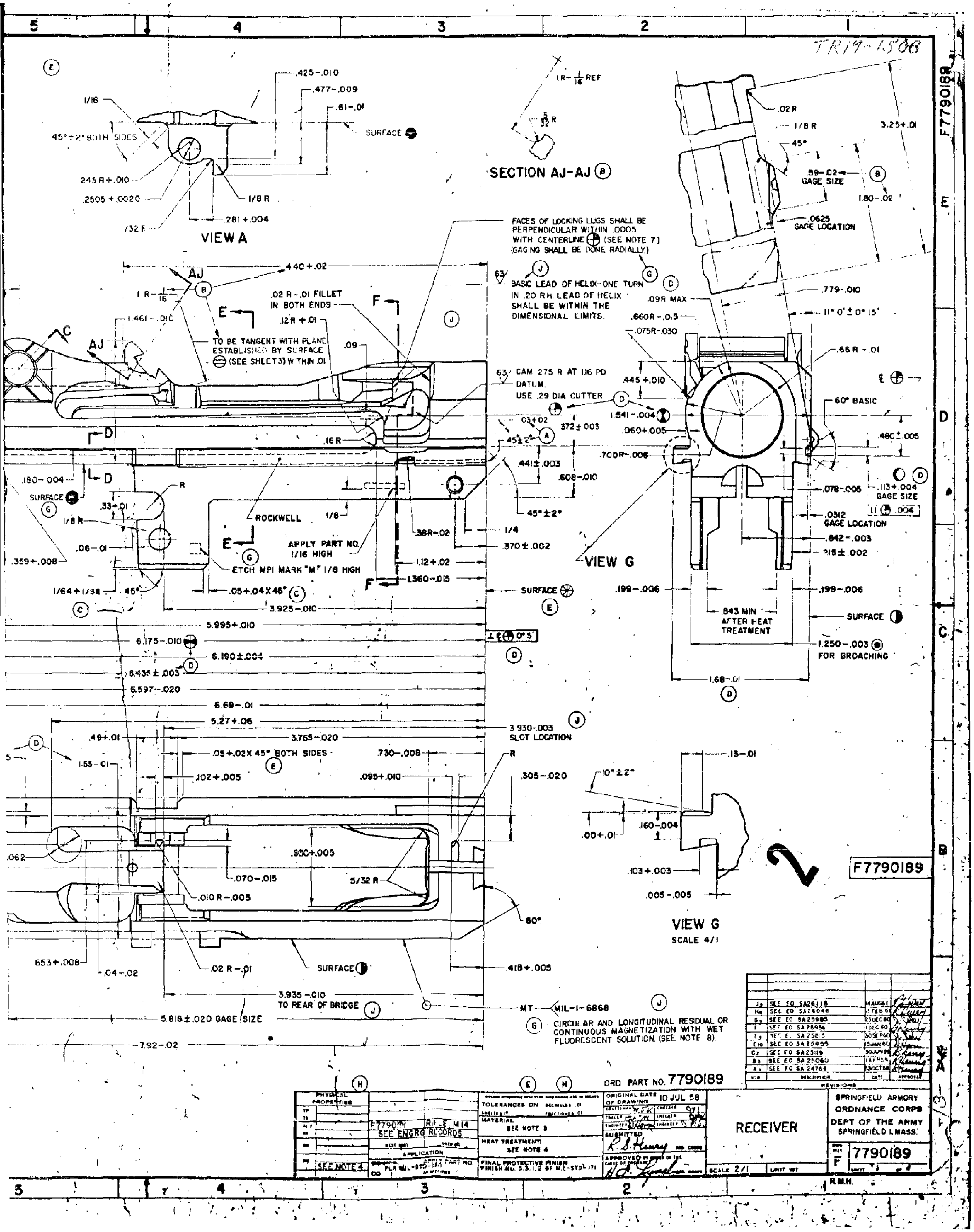




4. HEAT TREATMENT: THE FOLLOWING REQUIREMENTS ARE MANDATORY. NORMALIZE BEFORE MACHINING. CARBURIZE AT 1550°F TO 1600°F TO CASE DEPTH .012 TO .018. OIL QUENCH FROM 1550°F TO 1600°F. TEMPER ONE HOUR MINIMUM AT 400°F TO 450°F TO HARDNESS SPECIFIED. SURFACE ROCKWELL C61 TO C69. CORE ROCKWELL C31 TO C42. MICROSTRUCTURE OF CORE SHALL NOT CONTAIN MORE THAN 10% FREE FERRITE AFTER HEAT TREATMENT. THE USE OF A STRAIGHT CYANIDE BATH OR GAS PROCESSES SHALL NOT BE PERMITTED.

8. AFTER HEAT TREATMENT, EACH RECEIVER SHALL BE FREE FROM CRACKS, SEAMS AND OTHER INJURIOUS DEFECTS AS DETERMINED BY MAGNETIC PARTICLE INSPECTION USING A STANDARD 5 TURN MAGNETIZING COIL WITH A CURRENT OF 800 TO 1200 AMPERES.

1



TR19-1508
F7790189
VIEW A
.425-.010
.477-.009
.61-.01
1/16
45°±2° BOTH SIDES
SURFACE
245 R+.010
.2505+.0020
1/8 R
1/32 R
.281+.004
1 R-1/16 REF
3/32 R
SECTION AJ-AJ (B)
FACES OF LOCKING LUGS SHALL BE PERPENDICULAR WITHIN .0005 WITH CENTERLINE (SEE NOTE 7) (GAGING SHALL BE DONE RADIALLY.)
BASIC LEAD OF HELIX-ONE TURN IN .20 R.H. LEAD OF HELIX SHALL BE WITHIN THE DIMENSIONAL LIMITS.
.02 R
1/8 R
45°
3.25+.01
.59-.02 GAGE SIZE
1.80-.02
.0625 GAGE LOCATION
.779-.010
.09R MAX
.660R-.05
.075R-.030
11° 0'±0° 15'
.66 R-.01
60° BASIC
.4.40+.02
AJ
1 R-1/16
1.461-.010
.02 R-.01 FILLET IN BOTH ENDS
.12R+.01
TO BE TANGENT WITH PLANE ESTABLISHED BY SURFACE (SEE SHEET 3) WITHIN .01
.09
CAM 275 R AT 116 PD DATUM. USE .29 DIA CUTTER
.445+.010
1.541-.004
.060+.005
.700R-.006
.480-.005
.03+.02
.372±.003
45°±2°
.16R
.441±.003
.608-.010
.180-.004
SURFACE
.33+.01
1/8 R
.06-.01
.359+.008
ROCKWELL
1/16
APPLY PART NO. 1/16 HIGH
ETCH MPI MARK "M" 1/8 HIGH
.38R-.02
1/4
.370±.002
45°±2°
VIEW G
.078-.005
.113+.004 GAGE SIZE
.0312 GAGE LOCATION
.842-.003
.215±.002
1.12+.02
1.560-.015
1/64+1/32
45°
.05+.04X45°
3.925-.010
SURFACE
.199-.006
.199-.006
.843 MIN AFTER HEAT TREATMENT
SURFACE
5.995+.010
6.175-.010
6.190±.004
6.435±.003
6.597-.020
6.69-.01
1.250-.003 FOR BROACHING
1.68-.01
5.27+.06
.49+.01
3.765-.020
3.930-.003 SLOT LOCATION
.05+.02X45° BOTH SIDES
.730-.008
1.55-.01
.102+.005
.095+.010
R
.305-.020
.15-.01
10°±2°
.00+.01
.160-.004
.062
.930+.005
.070-.015
5/32 R
.010R-.005
.103+.003
.005-.005
VIEW G SCALE 4/1
80°
653+.008
.04-.02
.02 R-.01
SURFACE
.418+.005
3.935-.010 TO REAR OF BRIDGE
MT—MIL-I-6868
CIRCULAR AND LONGITUDINAL RESIDUAL OR CONTINUOUS MAGNETIZATION WITH WET FLUORESCENT SOLUTION. (SEE NOTE 8).
5.818±.020 GAGE SIZE
7.92-.02
SEE EO SA26118
SEE EO SA26046
SEE EO SA25885
SEE EO SA25916
SEE EO SA25815
SEE EO SA25855
SEE EO SA25119
SEE EO SA25060
SEE EO SA24768
REVISIONS
ORD PART NO. 7790189
PHYSICAL PROPERTIES
F7790 RIFLE, M14
SEE ENGRG RECORDS
APPLICATION
SEE NOTE 4
TOLERANCES ON DECIMALS .01 FRACTIONS .01
MATERIAL SEE NOTE 3
HEAT TREATMENT SEE NOTE 4
FINAL PROTECTIVE FINISH
ORIGINAL DATE OF DRAWING 10 JUL 58
RECEIVER
SPRINGFIELD ARMORY ORDNANCE CORPS DEPT OF THE ARMY SPRINGFIELD MASS.
F 7790189
SCALE 2/1
R.M.H.

I. Nondestructive Material Segregation Studies

A. Investigations on Fractured Receivers

Chemical and metallurgical data were compiled on fractured receivers, "Code OH' 19478 and "Code HG' 73293. Chemical data are shown in Table 1. Receivers were found to have been fabricated from 1330 material. Damaged receivers and receiver fractures are pictured in Figures 1-4. A photomicrograph of the structure in "Code HG' receiver 73293 is shown in Figure 5.

TABLE 1

Chemical Data on Fractured Receivers

Element	Specification Requirement 8620H Resulphurized	"Code OH' 19478	"Code HG' 73293
Carbon	0.17 - 0.23	0.30 0.31	0.30 0.31
Manganese	0.60 - 0.95	1.79	1.81
Silicon	0.20 - 0.35	0.29	0.20
Sulfur	0.035 - 0.050		0.041
Phosphorous	0.040 Max.	0.054	0.054
Chromium	0.35 - 0.65	0.20	0.20
Nickel	0.35 - 0.75	0.14	0.14
Molybdenum	0.15 - 0.25		

Metallurgical data showed that fractured receivers had extremely high core hardness, Rockwell C 51-53.5. Microstructures were predominately martensite and lower bainite. Currently specified core hardness for 8620H resulphurized receivers was Rockwell C 31-42, structures normally contained greater amounts of upper bainite than evidenced in the fractured receivers.

B. Receiver Material Segregation Studies

In addition to investigations on fractured receivers at the problem outset, many individuals and installations were contacted relative to methods and approaches to use for segregation of mixed material receivers. Most suggested a chemical spot test with philosophy based on the expected quantities of certain elements in the 8620H steel as compared to 1330 steel. The presence of residual alloy in the 1330 steel used, together with the possibility that other spurious material might be involved made these methods unreliable. Along the same lines Watertown Arsenal proposed separation methods employing x-ray spectroscopy and neutron activation of manganese.

B. Receiver Material Segregation Studies - Continued

Electromagnetic methods were finally selected as the most economical and offering the best possibility for solution. Approach by these methods was complicated however, in that only small sections of ruptured 1330 steel receivers were available for initial tests. A complete receiver of the unwanted material was required for use as a comparison standard. It was not considered advisable to fabricate receivers from 1330 material because of the problem urgency, the time and expense required to fabricate complete receivers, and the uncertainty as to materials which might also be mixed.

Work conducted with electromagnetic methods in segregation of spurious material comprised three separate studies; initial screening, test development, and correlation.

C. Initial Screening Studies - Material Segregation

1. Procedure

The purpose of initial screening studies was to obtain a complete receiver fabricated from 1330 material and to determine whether this represented the only mixed material. The approach taken was that of examining as large a number of receivers with magnetic equipment, with the hope that nondestructive spectrographic tests on those displaying the greatest differences would result in finding a complete 1330 receiver. Test data were gathered at contractor plants employing three different magnetic equipments. (Magnatest FS-300, Magnetic Analysis Production Comparator, and Magnatest ED-500). Tests were concentrated on receivers in the heat lot from which failed components had come. The procedure involved recording the receiver serial number and the test reading on each instrument. All readings, such as amplitude and phase of the fundamental and harmonic waves were recorded. Receivers were next carefully selected and analyzed spectrographically.

2. Results

Tests conducted with the Magnetic Analysis Production Comparator noting amplitude of wave forms, phase shift, and harmonic content resulted in the discovery of 1330 material receivers. Data sheets recording receiver serial numbers, electromagnetic test readings, and spectrographic results are shown in Appendix A, Section 1. Receivers made of 13XX material had high plus readings and wave patterns contained all third harmonic content with and without phase shifts. Receivers made of 86XX

C. Initial Screening Studies - Material Segregation

2. Results - Continued

material showed third and fifth harmonic contents with most readings less positive than noted with 13XX material receivers. The purpose of the studies, that of obtaining complete receivers made of 13XX material, was accomplished. Studies indicated method feasibility as differences in magnetic properties resulted in detection of spurious material. In addition, a second mixed steel was found, an alloy containing approximately 4 per cent nickel.

D. Test Development Studies - Material Segregation

1. Procedure

With receivers of different known chemical compositions available, test development studies employing various magnetic equipment (Magnetic Analysis Production Comparator and Magnatest FS-300) were begun. Various test set-ups at different sensitivities were investigated to determine acceptance range, sensitivity required, and optimum test parameters. Variables which might affect measurements were studied. Investigations were made on (1) parkerized and unparkerized receivers, (2) receivers assembled in weapons and those unassembled, (3) effect of residual magnetism, (4) effect of retained austenite, (5) effect of temperature of receivers at test and (6) effects of tempering and retempering receivers at various temperatures.

2. Results

Studies resulted in the development of a magnetic test method employing Magnetic Analysis Production Comparator equipment for segregation of mixed material receivers. Initial screening studies employed unfiltered 60-cycle secondary coils. Further tests indicated a better separation was obtained with the use of a filtered 60-cycle operation. Data sheets on gathered information are shown in Appendix A, Section 2. Standards were selected and equipment calibrated such that the 13XX series gave high plus readings in excess of +95. Properly treated 86XX components now gave readings which were no greater plus than +39. High nickel alloy material gave a negative off-scale reading with a large phase shift; 86XX material showed negative readings as high as minus off-scale, but phase shifts were not as great as with the high nickel material. Equipment could have been set such that 13XX series could have been represented by excessive negative readings by reversing polarity. Method was chosen however to differentiate material in the plus direction. Photographs of the equipment, meter readings, and scope patterns are shown in Figures 6 and 7.

D. Test Development Studies - Material Segregation

2. Results - Continued

It was discovered that components had varying degrees of retained magnetism which greatly affected test results. The more magnetized a receiver, the greater was the instrument plus reading. A field intensity meter was required to check for retained magnetism before testing. Demagnetization was required on receivers which were magnetized. Retained austenite and temperature of receivers at test had little effect on readings. Parkerized and unparkerized receivers did not change readings noticeably. Changes in readings were noted with barrels, rear sights, etc., attached. It was necessary to make certain, when particular assembly was tested, that all standards had similar parts attached. It was required to check the degree of magnetism of attached parts, and demagnetize them if magnetized. Variations in tempering and retempering had a great effect on readings. Results are reported in the following section.

E. Correlation Studies - Material Segregation

1. Procedure

Additional confirming data were required on a large number of receivers before the test could be proved for inspection of components. The remainder of the receivers in heat lot B, from which ruptured receivers had been found, were tested. Total tested amounted to 554 receivers.

Distribution of test readings was also studied. Distribution results were first plotted on receivers in "Code HG", Lot B. Additional data were compiled on 100 Springfield Armory receivers from different heat lots and on 180 Code HG' receivers taken from delivered weapons and representing different heat lots. Because deviations in distributions were noted, the cause of these deviations were investigated. Electromagnetic test readings were recorded on 25 known 8620H material receivers which gave various negative readings. Metallurgical examinations of structure, surface and core hardness in various areas, and measurements of case depth were made. A more detailed retemper study was also undertaken.

Magnetic readings on receivers were recorded; receivers were then retempered and reread. This procedure was followed until magnetic readings were minus off scale.

2. Results

Spectrographic results gave 100% correlation with electromagnetic test results. Previously compiled spectrographic data are shown in Appendix A, Section 2. Results on the remainder of the lot tested are listed in Appendix A, Section 3. A total of 543 were

E. Correlation Studies - Material Segregation

2. Results - Continued

analyzed as 86XX series, 10 as 13XX series, and 1 as high nickel alloy. Prior magnetic tests resulted in an identical breakdown on the same receivers.

Distribution curve of electromagnetic test readings on the 554 "Code HG" receivers displayed primarily a range of -40 to +40 in readings (Chart 1). The 100 Springfield Armory receivers tested had a similar distribution (Chart 2), with the distribution for "Code HG" shifted slightly negative and the Springfield Armory receivers shifting slightly positive.

A further study of the 180 "Code HG" receivers from various heat lots (Chart 3) resulted in a wide deviation in distribution. Greater negative readings were predominant; a large percentage fell outside the -40 reading, particularly in Lots C and E. The cause of readings more negative than -40 was attributed to three conditions: generally, low core hardness, sections locally annealed, and receivers tempered or retempered at relatively high temperatures. The receiver and the sections on which direct core Rockwell C measurements were made are shown in Figure 8. Surface and core hardness, and microstructure and case depth data are shown in Tables 2-5. Significant information is obtained by comparison of hardness in identical sections, such as areas A, B, C, etc. Table 2 indicates that, when negative readings greater than -40 were obtained, the hardness in the lug section (areas F and G) was probably below C30.

CHART 1 - DISTRIBUTION OF TEST READINGS ON 554 "CODE HG" RECEIVERS FROM HEAT LOT B

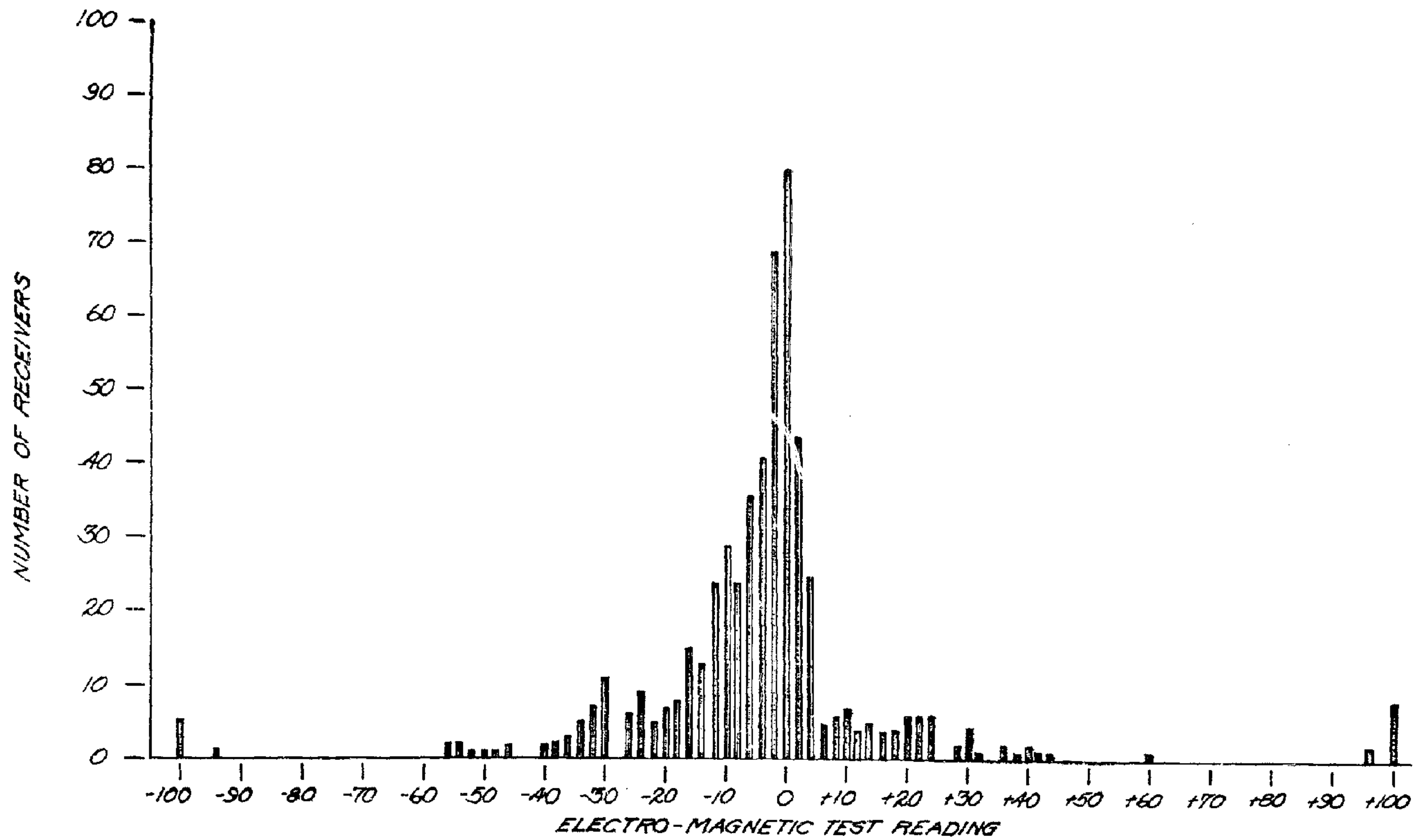


CHART 2 - DISTRIBUTION OF TEST READINGS ON 100 S.A. RECEIVERS

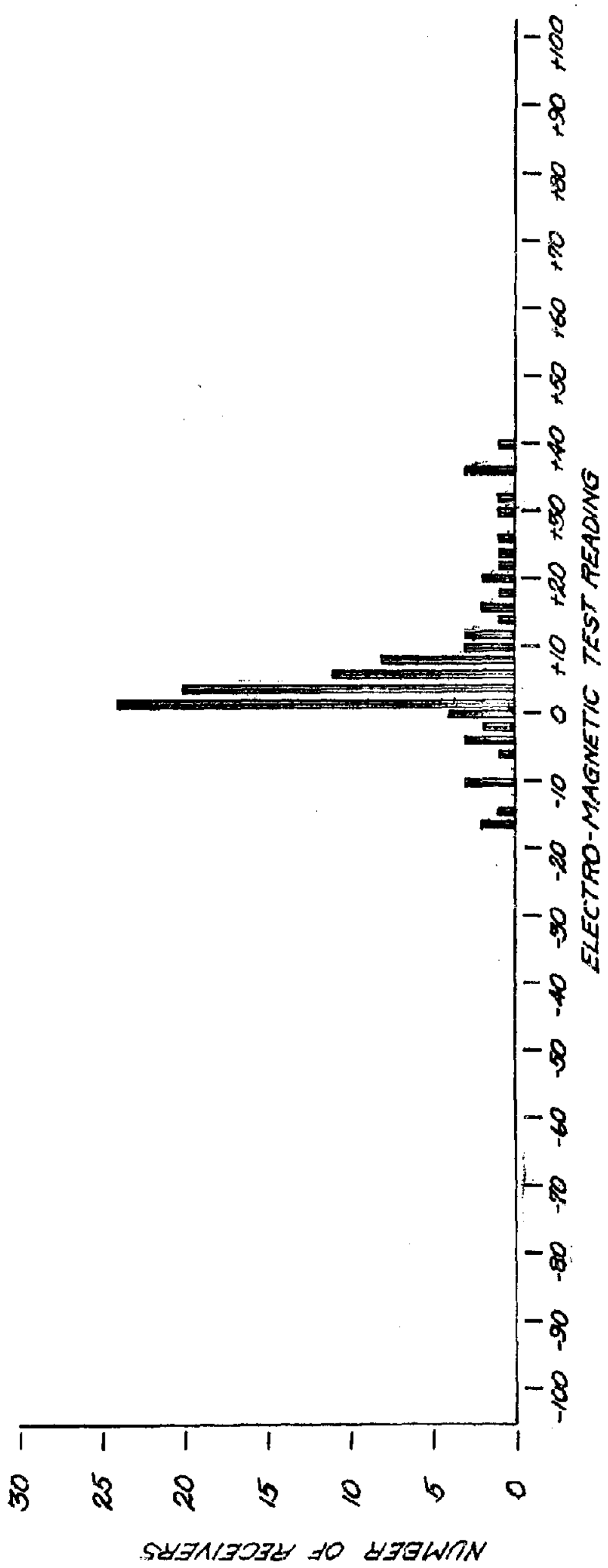


CHART 3 -DISTRIBUTION OF TEST READINGS ON 180 "CODE HG" RECEIVERS FROM VARIOUS LOTS

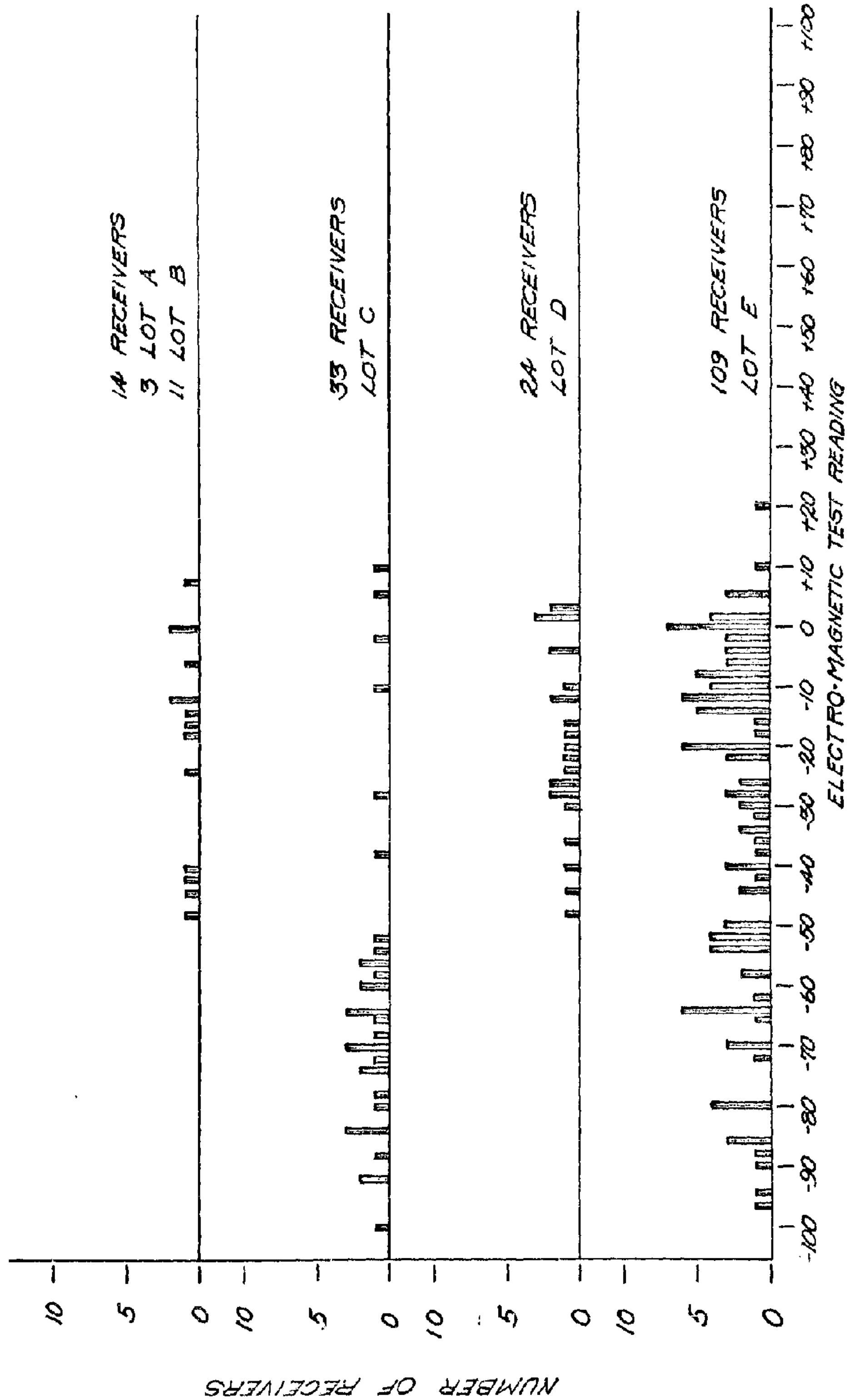


TABLE 2 – SURFACE AND CORE HARDNESS MEASUREMENT DATA

RECEIVER IDENTITY	MAGNETIC ANALYSIS READING	SURFACE		CORE HARDNESS OF SECTIONS									
		R_D	R_C	A	B	C	D	E	F	G	H	I	J
CODE No 76344	–3	65-69	50-52.5	28.5-29	27-27.5	26.5	25.5	30-31	29.5-31.5	29.5-33.5	37-40.5	41-41.5	35.5-37.5
" 79209	–8	66-68	52-54	33.5-34.5	31	29-29.5	31.5	39-39.5	38-39	33.5	40.5-42.5	41.5-43.5	40-43
" 76041	–12	66-68	52-54	34.5-36	34.5-35	31.5-32.5	34-34.5	38-38.5	37.5-38	40.5-43	42-43	44.5	43.5-44.5
" 69529	–25	67-68	54-55	37.5-39.5	38.5-40.5	36-36.5	36.5	39-39.5	37.5	42.5-44.5	44-44.5	45.5	45-46.5
" 77068	–35			30-31.5	28-30.5	29-29.5	28-30.5	36.5-37.5	37-37.5	36.5-37	38.5-39	42.5-43.5	43.5-45.5
" 75198	–35			31.5-32	28.5-29.5	29.5-30	34-34.5	41.5-43.5	36.5	33-34.5	42-44	43-45.5	43.5-46
" 67735	–40			28.5-29.5	27.5-28	25.5-26.5	28-31	31.5-34	24.5-25.5	31-32.5	37.5-38.5	41.5	40.5-41
" 80162	–40			27-28	25.5-26	23-24.5	27-27.5	30-33	30-31	28.5-30.5	36-43	41.5-43	37.-38.5
" 77128	–45			31.5-32.5	27.5-29	28.5	27.5-30	31-33.5	33-35	35.5-36.5	38.5-39	42.5	42-43
" 77685	–50			24-24.5	20.5-23.5	22.5	24.5-25	24-26	27-28	25-25.5	26-31.5	31-33.5	30.5
" 78536	–50			23-24.5	23-25.5	23.5-24.5	24-26	25-25.5	27.5-28.5	28.5-29	34-38	34-35.5	35-37
" 79132	–50			22.5-24.5	22-23.5	21.5-22	25	28-29	26-27.5	24-25.5	32-36.5	30-33.5	29-30.5
" 79258	–50			25-26	23-24.5	23.5-24	24-26	26-26.5	28-30.5	26.5-28	28-32	32-34	33-35
" 73978	–50	64-65	48.5-49.5	23-24	21.5-23.5	23.5	24.5-25.5	26.5-28	26.5-27.5	28-29	33-35	33.5-34.5	30-31
" 71380	–55	65.5-68	51-52	23-25	22.5-23.5	21.5-22.5	26	26-28	23.5-30.5	24-24.5	33-34	33.5-34.5	34.5-35.5
" 81497	–55			23.5-25	23-24.5	24-25	25.5-26.5	26.5-28.5	27-28	26.5-27	29.5-34	31-32.5	31.5-32
" 76336	–55			23-24.5	23-25.5	23.5-24	24-26	25-25.5	27.5-28	28.5-29	34-36	34-35.5	35-37
" 76335	–55			21.5-23	16.5-20.5	19-24	23-23.5	25-27	24.5-25	24.5-26	32-36.5	34-35	35-37
" 50295	–55	63-65	49-51	24	22-23	21-22.5	22-24	24.5-27	24-26	22.5-25.5	27.5-31.5	33-34	34.5
" 76716	–75	59.5-62	44.5-46	21.5-24	18.5-20	18-18.5	21.5-23.5	24.5-25	18.5-24.5	20.5	26-35	29.5-31	29.5-30.5
" 76940	–85	63-63.5	46.5-48.5	20.5-23.5	21-23	22	24	25.5-27.5	25-25.5	24-25.5	26-28.5	28.5-32	35.5-37
" 78799	–90	61.5-62.5	43.5-47.5	22.5-24.5	20.5-23.5	20.5-22.5	23-23.5	25-29	23.5-25.5	25-26.5	27.5-30.5	29-32	29.5-31
" 73345	–100	59.5-63	42.5-46	25	20.5-25	23.5-25	26.5-27.5	26.5-27.5	15-18.5	23-25.5	31.5-32	31-32.5	26.5-28.5

TABLE 3
STRUCTURE DATA – RECEIVER RING SECTION

RECEIVER IDENTITY	MAGNETIC ANALYSIS READING	HARDNESS			MICROSTRUCTURE			CASE	
		R_A	R_C (CONV)	R_C (DIRECT)	FREE FERRITE	UPPER BAINITE	MARTENSITE AND LOWER BAINITE	DEPTH (INCHES)	RETAINED AUSTENITE
"CODE HG" #76344	-3	64-65	27-29	27.5-28	5-10%	40-65% COARSE	REM.	.011-.013	100% TO .001"-.0015"
" #79209	-8	66.5-67	32-33	33-35.5	5-10%	40-60%	"	.012-.014	100% TO .001"-.0015"
" #78041	-12	66-68	34-35	34.5-36	0-5%	25-35%	"	.011-.013	100% TO .0015"-.002"
" #69529	-25			35-38	5-10%	35-55%	"	.009-.013	100% TO .0005"-.001" 45-25% TO .003"
" #79972	-50			24.5	5-10%	50-80% VERY COARSE	"	.012-.014	100% TO .001"
" #71980	-55	63.5	26	26-27.5	5-10%	45-70% VERY COARSE	"	.012-.014	100% SUPERFICAL 40-25% TO .003"
" #80295	-65	63	25	24-25.5	5-10%	50-80% VERY COARSE	"	.012-.015	100% TO .001"
" #76716	-75			24-26.5	10-20%	35-70%	"	.009-.013	100% TO .0005"-.0015"
" #76940	-85			24-25.5	5-10%	55-85% COARSE	"	.008-.010	100% TO .0005"
" #78799	-90	62-63	23-25	24.5-25	5-10%	40-75% VERY COARSE	"	.013-.014	100% SUPERFICAL 25-10% TO .003"
" #75345	-100	64-65.5	27-29	26.5-28	35-45%	TRACES	"	.016-.017	100% TO .004"

TABLE 4

STRUCTURE DATA – RECEIVER LUG SECTION

RECEIVER IDENTITY	MAGNETIC ANALYSIS READING	HARDNESS			MICROSTRUCTURE			CASE	
		R_A	R_C (CONV)	R_C (DIRECT)	FREE FERRITE	UPPER BAINITE	MARTENSITE AND LOWER BAINITE	DEPTH (INCHES)	RETAINED AUSTENITE
"CODE H" #76344	-3	65.5-67.5	30-34	30-34	5-10%	40-70% VERY COARSE	REM.	.013-.014	100% TO .001"
" #79209	-8			38-42	3-7%	10-25%	"	.014-.015	40-25% TO .003"
" #78041	-12	69.5-70	38-39	35-40	3-7%	15-30%	"	.012-.014	70-25% TO .004"
" #69529	-25	68.5-69.5	36-38	39.5	3-7%	5-20%	"	.012-.014	70-0% TO .004"
" #79972	-50	64-64.5	27-28	26.5-28	0-10%	50-80% COARSE	"	.014-.017	100% TO .001"
" #71980	-55			{18-22 / 34-35}	3 ZONES 5-50%	70-80% VERY COARSE	"	.014-.015	25% - TRACE TO .002"
" #80295	-65	63	25	26.5	5-10%	40-75%	"	.017-.019	100% TO .001"
" #76716	-75	63-65	24-29	24.5-26.5	3-7%	60-80% VERY COARSE	"	.009-.011	20-0% TO .004"
" #76940	-85			26	10%	60-80% 1/2 COARSE	"	.009-.010	100% SUPERFICAL 20-15% TO .002"
" #78739	-90	62-63	23-25	24.5-25	5-10%	40-75% VERY COARSE	"	.013-.014	100% SUPERFICAL 25-10 TO .003"
" #73345	-100			{31-37 / 18}	— 40-55%				

TABLE 5

STRUCTURE DATA - RECEIVER RAIL SECTION

RECEIVER IDENTITY	MAGNETIC ANALYSIS READING	HARDNESS			MICROSTRUCTURE			CASE	
		R_A	R_c (CONV)	R_c (DIRECT)	FREE FERRITE	UPPER BAINITE	MARTENSITE AND LOWER BAINITE	DEPTH (INCHES)	RETAINED AUSTENITE
"CODE KG" #76344	-5				0-5	5-10%	REM.		55-35% TO .005"
" #79209	-8				0	TRACE	"		55-45% TO .006"
" #78041	-12				0	TRACE	"		45-55% TO .007"
" #69529	-25				0	TRACE	"		55-40% TO .005"
" #79972	-50				5-10%	35-45%	"		35-25% TO .004"
" #71980	-55				0-5%	10-15%	"		35-25% TO .005"
" #80295	-65				0-5%	35-45%	"		30-20% TO .005"
" #76716	-75				0-5%	35-45%	"		30-20% TO .005"
" #76940	-85				0-5%	20-30%	"		25-15% TO .003"
" #78799	-90				5-10%	20-30%	"		30-20% TO .003
" #73345	-100				45-55%	-REMAINDER	——		70-60% TO .002"

Table 6

Retempering Study

Receiver Identification	Condition	Treatment	Electromagnetic Test Reading
"Code HG" 66117	Unparkerized		+30
		Retemper 1 hr @ 400°F	+15
		Retemper 1 hr @ 400°F	+10
		Retemper 1 hr @ 425°F	- 2
		Retemper 1 hr @ 500°F	-105
SA 99987	Parkerized		- 8
		Retemper 1 hr @ 400°F	-16
		Retemper 1 hr @ 400°F	-19
		Retemper 1 hr @ 425°F	-28
		Retemper 1 hr @ 500°F	- Off scale
"Code HG" 69995	Parkerized		- 7
		Retemper 1 hr @ 500°F	- Off scale
"Code HG" 70093	Parkerized		+ 2
		Retemper 1 hr @ 500°F	- Off scale

E. Correlation Studies - Material Segregation - Continued

The hardness specified for this area is Rockwell C31-42. Hardness obtained in heavier sections of these receivers was softer than in the thinner sections.

Investigations revealed that material alterations can be detected. Metallurgical examinations of receiver 71980 revealed localized tempering or annealing. A photo micrograph of an area within this receiver is shown in Figure 9.

Results of the temper and retemper study showed that test readings were greatly changed when receivers were retempered. Results of this study are shown in Table 6. Data show that on retemper at 400°F, test readings changed 8 to 15 points in the negative direction; second retemper at 400°F changed readings 3 to 5 points further negative. On retemper at slightly higher temperature (425°F) readings were altered 8 to 12 points in the negative direction. Readings changed radically to minus off scale when receivers were tempered at 500°F. Two additional receivers retempered directly at 500°F gave readings of minus off scale. Thus, results indicate that tempering significantly altered magnetic readings. Hardness and structure examinations showed that corresponding property changes were small. Greatest effect was noted on the surface with little effort on the core. Tempering in itself is generally considered to be beneficial, but near 500°F for 8620H material it was shown that material was approaching a "blue brittle range" wherein impact strength dropped sharply. Based on the results of all above studies, the acceptance range of +40 to -40 was established for receivers of 8620H material for the segregation program.

F. Segregation Program

Tests on receivers were conducted at contractor plants and at Raritan Arsenal after a high level assurance of material separation was obtained. Receivers were gathered with various established magnetic readings for use in setting up equipment and as standards of acceptance. These were supplied contractors and inspection personnel. Instructions on the separation were detailed, inspection personnel instructed, and the test was put into operation. Periodic checks were made of test procedures and equipment calibration.

Initially at Raritan Arsenal, receivers were segregated on basis of acceptance range - -40 to +40. After 7,800 had been so inspected, because of urgent need for assembled weapons, the -40 limit was waived by higher authority to permit greater acceptance of material.

F. Segregation Program - Continued

A total of 35,786 weapons were segregated and receivers inspected together with those accounted for in this report, all subsequent production has been similarly inspected. Thirty-four receivers of 1330 material were found; only one receiver of high nickel alloy material was found.

II. Non-Destructive In-Process Inspection Studies

A. Distribution Studies of Magnetic Comparator Readings

Magnetic test acceptance range for the segregation program was based on a limited number of receivers because of the urgent need of segregating receivers for weapon reassembly. A program was initiated to further study the possible application of the electromagnetic test method used in segregation to the in-process inspection of receivers to control quality. Distributions of magnetic readings were obtained on receivers manufactured at "Code OH", at "Code HG", and at Springfield Armory. Receivers were tested from all heat lots available; process methods used in manufacture were noted in detail. Receivers were then selected representative of distributions obtained and spectrographically and metallurgically examined. Test procedures varied at each plant because of receiver quantities on hand and their availability for tests.

1. Distribution Studies "Code OH" Receivers

a. Procedure

At "Code OH", receivers were not readily available nor were various heat lots maintained separate. As such, it was impossible to obtain magnetic distribution data as sought in the formulated program. Work conducted was as follows: Sixty receivers prior to heat-treat were segregated by the contractor into three groups, designated as O, I, and U. Segregation was performed employing the magnetic analysis comparator equipment with an unheat-treated receiver used as a reference. Group O represented unheat-treated receivers with high plus readings, Group I unheat-treated receivers in the middle of range, and Group U unheat-treated receivers with high negative values. Receivers within these groups were heat-treated alike by the contractor, retested on the magnetic comparator employing standard segregation procedure, and metallurgically and chemically examined. Heat-treatment was as follows: Carburized at 1550^{o}F for

1. Distribution Studies "Code OH" Receivers

a. Procedure - Continued

2-1/2 hours, oil-quenched, and tempered at 425°F for 1 hour.

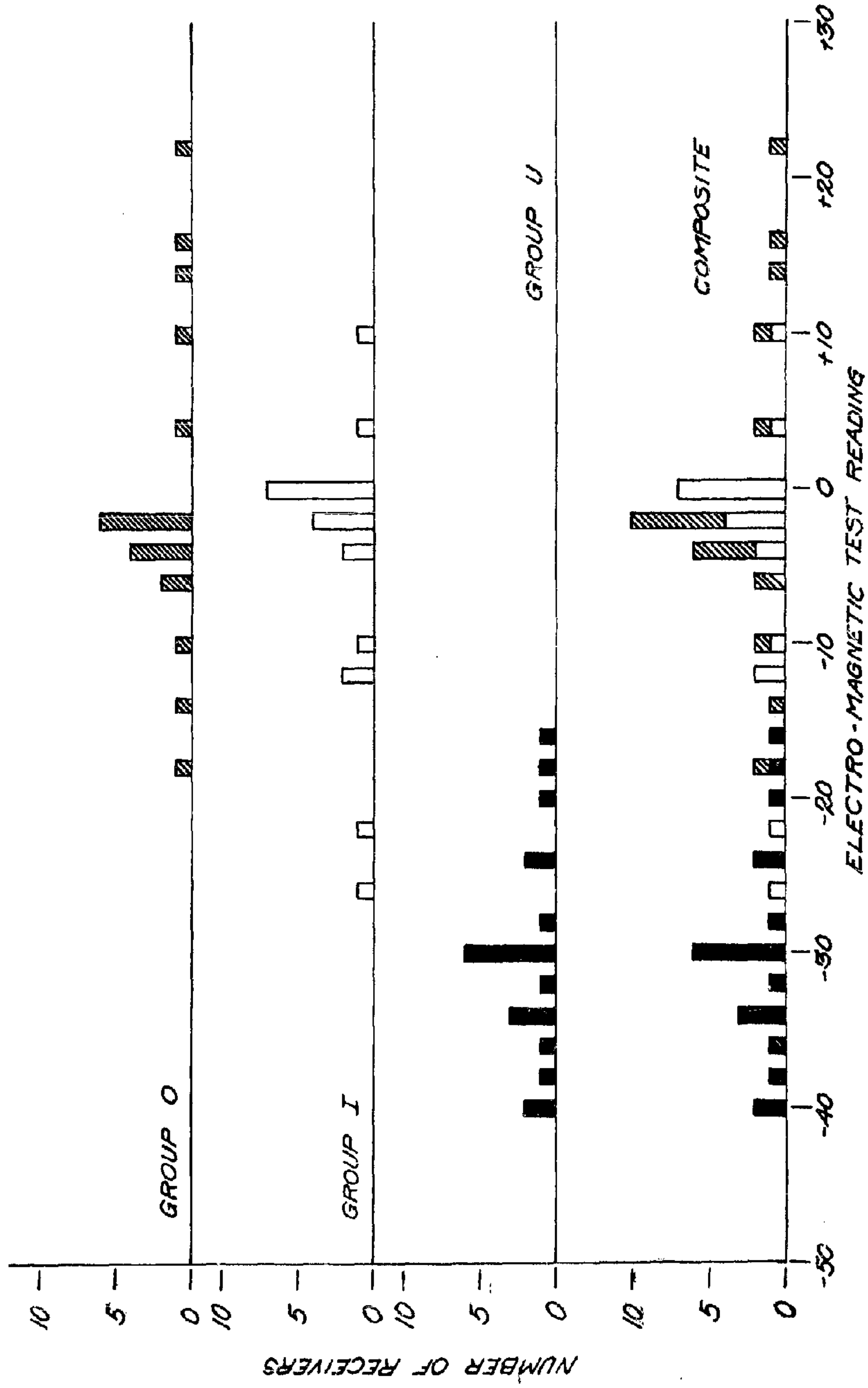
An additional twenty-eight receivers from "Code "OH" were selected prior to heat-treatment according to Groups O, I, and U and experimentally heat-treated by the contractor. Carburizing temperature and time were varied while quenching oil agitation, tempering time, and tempering temperature were maintained constant. Receivers in each group were carburized at either 1550°F or 1600°F for 1-1/2 or 2-1/2 hours. Magnetic data were gathered and receivers were examined metallurgically and chemically.

b. Results

The distribution of magnetic comparator readings prior to heat-treating on the 60 heat-treated receivers designated by the contractor as within segregated Groups O, I, and U ranged from +22 to -40. Distribution results are shown in Chart 4, composite and individual group distributions are shown. Groups O and I had essentially the same distribution; Group U distribution shifted more negative.

Metallurgical examinations were conducted at Springfield Armory and at "Code OH". Examinations revealed wide differences in material properties within the various groups, although groups were heat-treated alike. At Springfield Armory, hardness measurements and core structure examination on ten receivers indicated that Group O had high core hardness (Rc 39-42) and acceptable structure (1% max. ferrite), Group I medium core hardness (Rc 33-36) with acceptable structure (3-5% ferrite), and Group U core hardness below specification (Rc 23-29) with structure containing unacceptable percentages of free ferrite (5-17%). Spectrographic analysis of alloy constituents showed that some constituents decreased in same order as groups in which core hardness decreased; this indicated that Group O represented the highest hardenability steel and Group U the lowest hardenability. Rockwell D and C hardness measurements taken on rail and ring sections of these receivers showed that hardness of both sections within Groups O and I remained higher than that within Group U. Group U consistently indicated approximately 2 points lower Rockwell D and 5 points lower Rockwell C hardness in the ring section. Compiled metallurgical and spectrographic data on the ten receivers examined are shown in Table 7. Core hardness results of "Code OH" examinations on the remaining fifty receivers processed were similar to Springfield Armory results. Core hardness data compiled by "Code OH" are shown in Table 8.

CHART 4 -DISTRIBUTION OF TEST READINGS ON 60 "CODE OH" RECEIVERS SEGREGATED PRIOR TO HEAT TREATMENT



1. Distribution Studies "Code OH" Receivers

b. Results - Continued

Results on twenty-eight "Code OH" receivers experimentally treated are shown in Table 9. Receivers were treated in four series as follows: Series 1, Carburized at 1550° for 2-1/2 hours, oil-quenched, tempered at 425°F for 1 hour; Series 2, Carburized at 1550°F for 1-1/2 hours, oil-quenched, tempered at 425°F for 1 hour; Series 3, Carburized at 1600°F for 1-1/2 hours; oil-quenched, tempered at 425°F for 1 hour; Series 4, Carburized at 1600°F for 2-1/2 hours, oil-quenched, tempered at 425°F for 1 hour.

Hardness results were quite similar. Rockwell C and D hardness on the rail and the ring sections of receivers segregated as Groups O and I remained essentially the same compared with each other, although these hardnesses varied from series to series. Group U receivers consistently had lower Rockwell C and D hardness in the same sections. Group O receivers had high core hardness in each series with exception of those in Series 3. Group I displayed medium core hardness with exception of same Series 3. Group U receivers had core hardness below specifications in all series. Rockwell C and D hardness was lowest in receivers carburized at 1550°F for 1-1/2 hours; receivers carburized at 1550°F for 2-1/2 hours and those carburized at 1600°F for 1-1/2 hours had relatively the same hardnesses. Those carburized at 1600°F for 2-1/2 hours displayed highest Rockwell C and D hardness.

Magnetic readings were much the same in Series 1, 2, and 3 for the different groups. Series 4 had the highest readings. Magnetic data were similar to data in previous study on "Code OH" receivers.. Groups O and I had essentially the same readings within each series. Group U had the most negative readings.

This series of experiments carried out by "Code OH" provided the expected results. It is felt that the experiment would have been more practical if quenching speed had been varied so as to bring Group O down in hardness and to bring Group U (more drastically quenched) within the desired hardness range.

2. Distribution Studies "Code HG" Receivers

a. Procedure

Program effort was concentrated on receivers processed at "Code HG". Process information was maintained and large quantities of receivers were available for tests. In addition, information on daily metallurgical examinations conducted on receivers processed in each salt pot was obtainable. Distribution data were

TABLE 7 MAGNETIC, METALLURGICAL, AND CHEMICAL DATA ON 10 "CODE OH" RECEIVERS FROM VARIOUS GROUPS.

RECEIVER NO.	GROUP	MA READING	CORE		SURFACE HARDNESS				CHEMISTRY				
			HARDNESS Rc G AREA	% FREE FERRITE	RAIL		RING		Cr.	Si	Mn	Mo	Ni
					Ro	Rc	Ro	Rc					
28297	O	+22	39-40-41 41-41	1 MAX	70.5-70-70 69.5-69.5	59-58-57.5 57-57	70.5-70 70-69	57-56.5 56-55.5	.55-.55	.20-.21	.82-.77	.16-.16	.40-.38
28063	O	-2	39-41-41 42-42	1 MAX	71-70.5-70.5 70-69.5	58.5-58-57 57-56.5-55.5	68-67.5 67.5-67.5	54.5-54 54-53.5	.48-.44	.22-.22	.70-.64	.16-.16	.38-.40
26571	I	+11	31-32-33 34-35	3-5	72-69.5-69.5 68.5-68	57.5-56-55 55-55	68-67 67-66.5	54-53.5 53-52	.47-.45	.37-.25	.74-.70	.18-.18	.42-.45
27354	I	0	33-34-34 34-34	3-5	69.5-69.5-69 68-67.5	57-56-55.5 55.5-53.5	68.5-67.5 67.5-67.5	54-54 54-53.5	.48-.44	.28-.24	.80-.68	.22-.19	.40-.44
26040	I	-2	33-33-33 34-34	3-5	72.5-71.5-71.5 71-70	58.5-58-56 56-55	69-69 68-67.5	55.5-55.5 54-53	.47	.20	.68	.18	.40
29308	I	-10	35-35-35 36-36	2 MAX	69.5-69.5-68.5 68-66.5	57.5-56-54.5 54.5-53.5	69.5-68.5 68-67.5	55-54.5 54.5-53.5	.51	.20	.62	.20	.43
35847	U	-20	27-27-29 34-34	12-17	69.5-69-69 69-68.5	56-56-55.5 55-55	67-66.5 66-66	50-50 49.5-49	.39	.18	.63	.19	.41
34870	U	-30	24-24-25 25-25	5-15	70.5-69-69 69-69	56.5-56-55.5 55.5-54	69-67 66.5-66	50-49.5 49-46	.41	.15	.58	.19	.41
36187	U	-30	24-24-25 25-26	12-15	69.5-69-69 68.5-68.5	58-56-56 54.5-54	66-66 65.5-65	49.5-48.5 47.5-46.5	.39	.15	.57	.18	.44
36324	U	-40	23-24-24 25-25	8-12	68-68-68 68-67.5	56-56-55 54.5-53	66-66 65.5-65	49-49 48.5-47	.37	.17	.65	.19	.39

TABLE 8 CORE HARDNESS DATA COMPILED BY "CODE OH"

GROUP O		GROUP I		GROUP U	
RECEIVER	CORE HARDNESS R_c	RECEIVER	CORE HARDNESS R_c	RECEIVER	CORE HARDNESS R_c
28308	44-44-44-44-43-43	29246	33-35-37-36-35-36	31962	23-23-25-25-25-26
27909	38-39-40-41-42-44	26454	34-35-36-34-35-36	35474	21-24-24-26-26-27
27618	43-43-43-41-41-40	29209	37-37-39-39-39-39	30677	24-25-25-27-27-30
28223	42-43-43-42-41-41	26031	36-36-36-36-37-37	34300	25-25-26-27-27-28
28191	41-41-42-42-42-42	27073	39-40-41-36-36-36	36117	24-25-26-27-28-28
28078	38-38-40-39-40-42	27427	28-28-29-27-27-28	36001	24-27-28-25-27-28
28879	37-38-40-40-41-42	29402	37-38-38-35-36-37	36191	28-29-30-30-30-31
28794	40-42-43-42-43-42	26051	32-34-34-33-33-34	35932	22-24-25-26-26-28
28585	43-44-43-40-41-41	26599	28-31-33-34-34-35	35563	21-24-25-26-26-27
28408	41-42-42-40-40-40	26315	30-32-33-35-36-36	35488	26-26-27-28-28-29
26528	40-40-42-42-42-42	29364	25-26-27-25-27-28	36111	24-25-26-27-28-28
28259	45-45-45-45-44-43	26291	27-31-33-30-32-34	29902	24-24-25-25-27-28
25922	43-43-44-43-43-42	26084	28-28-29-29-29-29	35973	25-25-26-27-27-27
27672	44-44-43-43-43-42	25938	26-29-30-31-32-34	29525	27-28-28-29-29-29
28305	44-44-44-44-43-43	26141	33-33-35-36-37-38	35194	26-27-27-28-28-29
28293	43-43-43-44-43-43	26485	35-36-36-36-36-37		
28258	40-40-42-42-41-41				
24567	37-38-38-37-41-40				

TABLE 9 MAGNETIC AND HARDNESS DATA ON 28 "CODE OH" RECEIVERS EXPERIMENTALLY TREATED

RECEIVER NO.	GROUP	M.A. READING	CORE HARDNESS Rc G AREA	SURFACE HARDNESS			
				RAIL		RING	
				RD	Rc	RD	Rc
SERIES 1							
40701	O	+21	45-45-45	69-69-69.5	56.5-58-58.5	69.5-70.5-70.5	57.5-58-58
40600	O	+18	40.5-42-42	70-70-70	58-58.5-59	70-70-70	57-57-57.5
35034	O	+3	45.5-46-46	70-70.5-71-72	58-59-59.5	69.5-69.5-70	57-58-58.5
34980	I	+10	36-36.5-36.5	69-69-70.5-72	58-58.5-59	69.5-70.5-71.5	58.5-58.5-59.5
35428	I	+9	43-44-44	69.5-70-70	57-58-58	70-70-70	57.5-58-58
38630	I	0	36-36.5-36.5	69-69-69.5	58.5-59-59	68.5-69.5-71.5-72	57-57.5-58.5
40356	U	-32	25-26.5-27	69-70-70	54.5-55-56-58	68.5-68.5-69	53.5-54-55
SERIES 2							
40994	O	+6	44-44-45	67.5-68-68	53.5-53.5-54	68-68.5-68.5	54.5-55-56
35662	O	+5	37-37-37	67-68-68	52-54-55.5	68-68-68	53.5-54-54.5
35899	O	-2	41.5-42-42	67.5-68-68.5	52.5-53-54	67-68-68.5	50-51.5-53
35688	I	+11	34.5-35.5-36	66.5-67-68-70	53-53-53.5	68-68.5-69	54-54-54
40876	I	0	37.5-38-40	67.5-69-69	53.5-54-56	66.5-67-67	52-53-53.5
39782	I	0	35-35.5-36	65.5-66.5-68-69	53-53.5-54	66.5-66.5-67.5	50-52-52.5
35716	U	-31	25-25.5-25.5	67-67.5-68.5	52-53-53	61-62.5-62.5	45-45.5-45.5
35424	NOT MACHINED	-61	27-28-29	66-66.5-67	53-53.5-54	62.5-63.5-64	43.5-44-44.5
SERIES 3							
30513	O	+15	38-40-40.5	69-69.5-69.5-70.5	57-57.5-57-59-59	69.5-70-70	57-58-58.5
31554	O	-3	35.5-35.5-36	68-69.5-70.5-70.5	57.5-57.5-57.5-58.5	68.5-69.5-69.5	55.5-56.5-57
30899	I	+10	40-40-40	68.5-68.5-69-69.5	55.5-56-57-57.5	66.5-67.5-68-69.5	51-51.5-53-54
32682	I	+5	42.5-42.5-43	68-69-69-70.5	55.5-56-57-58	67.5-68.5-69	54.5-55-56
25705	I	-5	42-43-43.5	66.5-68-68.5-70.5-71	54.5-55.5-57.5-58	70-70-70.5	55.5-56-57-58
41231	U	-22	27.5-28-28.5	68.5-69-69-71	55-55-55.5-55.5	65.5-67.5-68	51.5-51.5-51.5
40623	U	-28	25-27-27.5	68-68.5-69.5-70	55-55.5-56.5-56.5	66-67-67.5	50.5-51-51.5
SERIES 4							
34050	O	+58	38.5-39.5-40.5	69.5-71-71-72	60-60-60.5	71.5-72-72	60.5-60.5-61
38098	O	+30	41.5-42-42	70-71-71-72	60-61-61	71-71.5-71.5	59-59.5-60.5
31731	O	+16	37-39-40.5	69.5-70.5-71-71.5	59.5-61-62	71.5-71.5-73	59-60.5-61
40143	I	+45	36-36-37	70-71-71.5-71.5	58-59-60	71-71.5-72	59-59.5-59.5
40597	I	+40	35-36-36.5	70-70-71-72	59-59-60	71.5-71.5-71.5	60-60-60.5
40312	I	+37	36-37.5-39	70-70.5-71-71	59-59.5-60	71.5-71.5-71.5	58.5-59-59.5

CHART 5 -DISTRIBUTION OF TEST READINGS ON "CODE HG" RECEIVERS FROM HEAT LOTS Q AND H

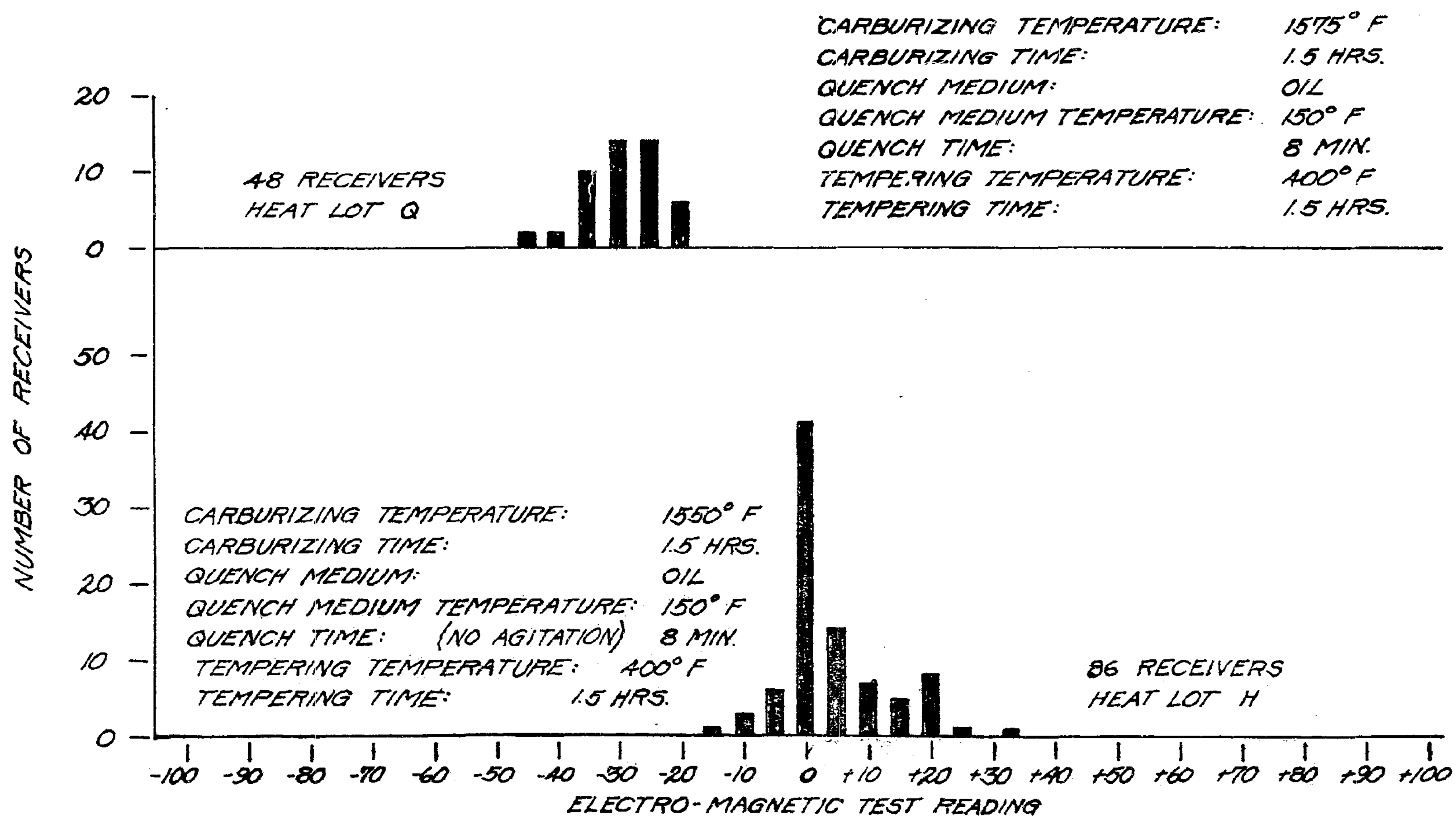


CHART 6 — DISTRIBUTION OF TEST READINGS ON 1391 "CODE HG" RECEIVERS FROM HEAT LOT N

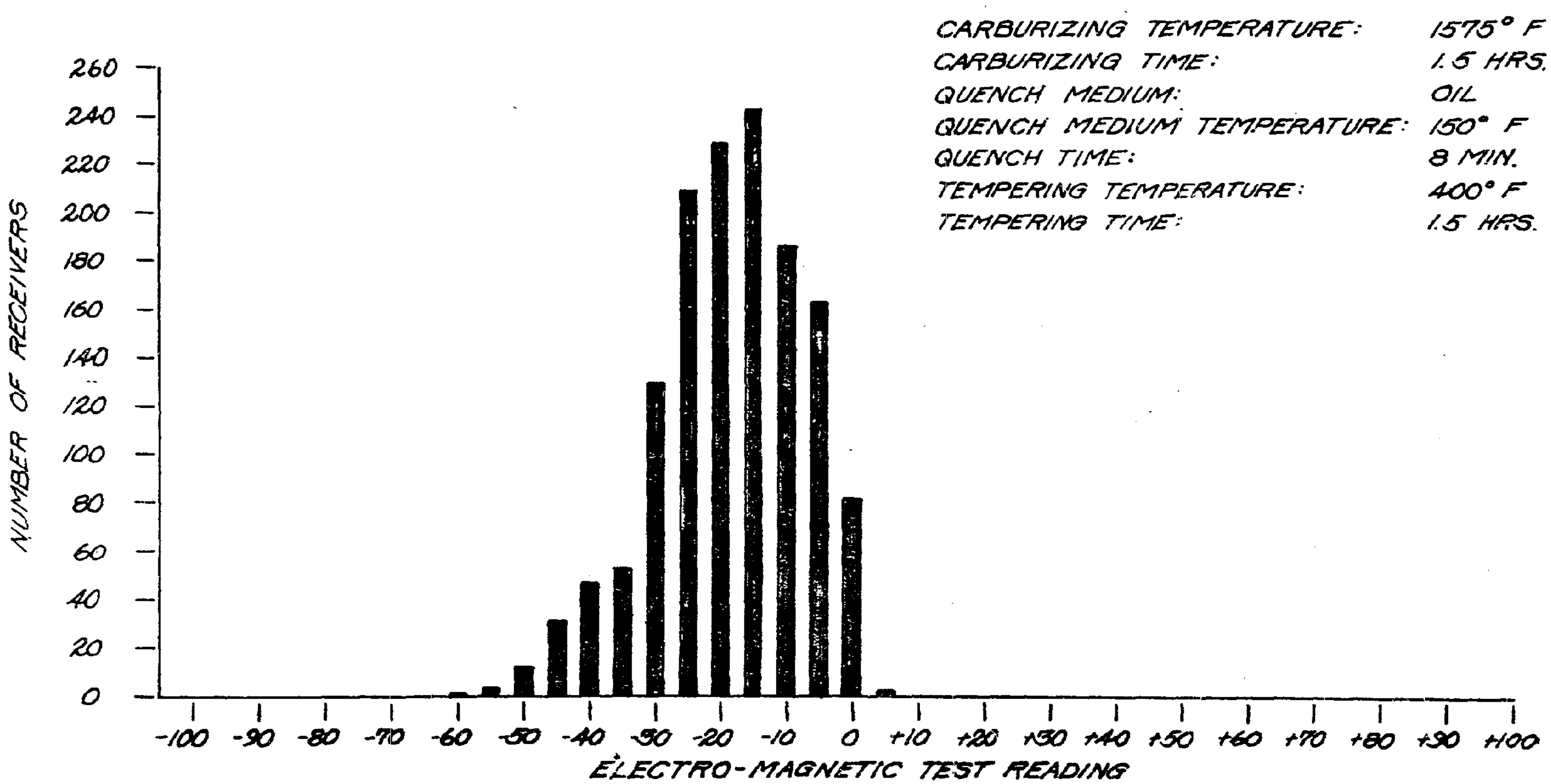


CHART 7 —DISTRIBUTION OF TEST READINGS ON 920 "CODE HG" RECEIVERS FROM HEAT LOT N'

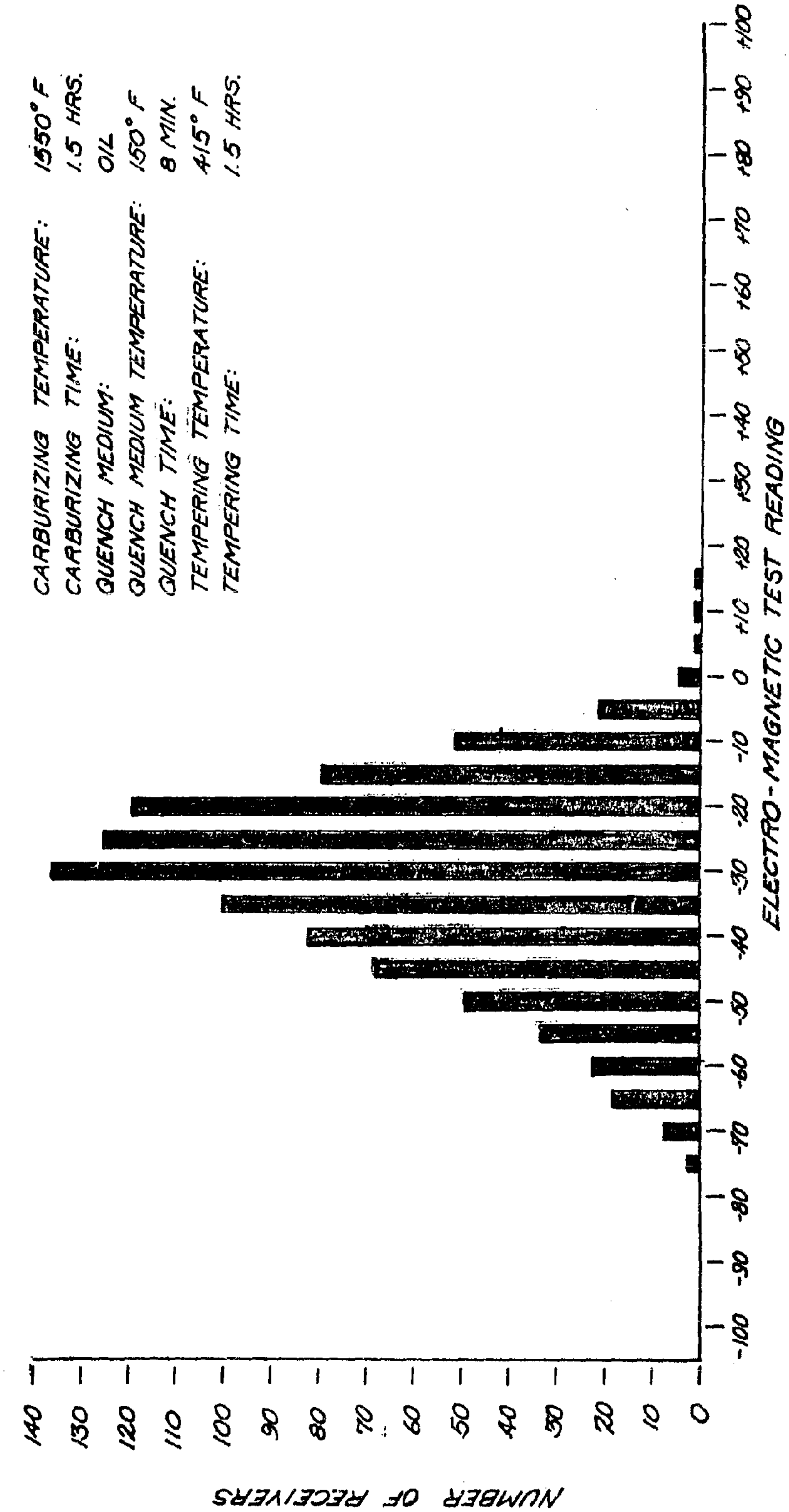


CHART 8 - DISTRIBUTION OF TEST READINGS ON 349 "CODE HG" RECEIVERS FROM HEAT LOT O

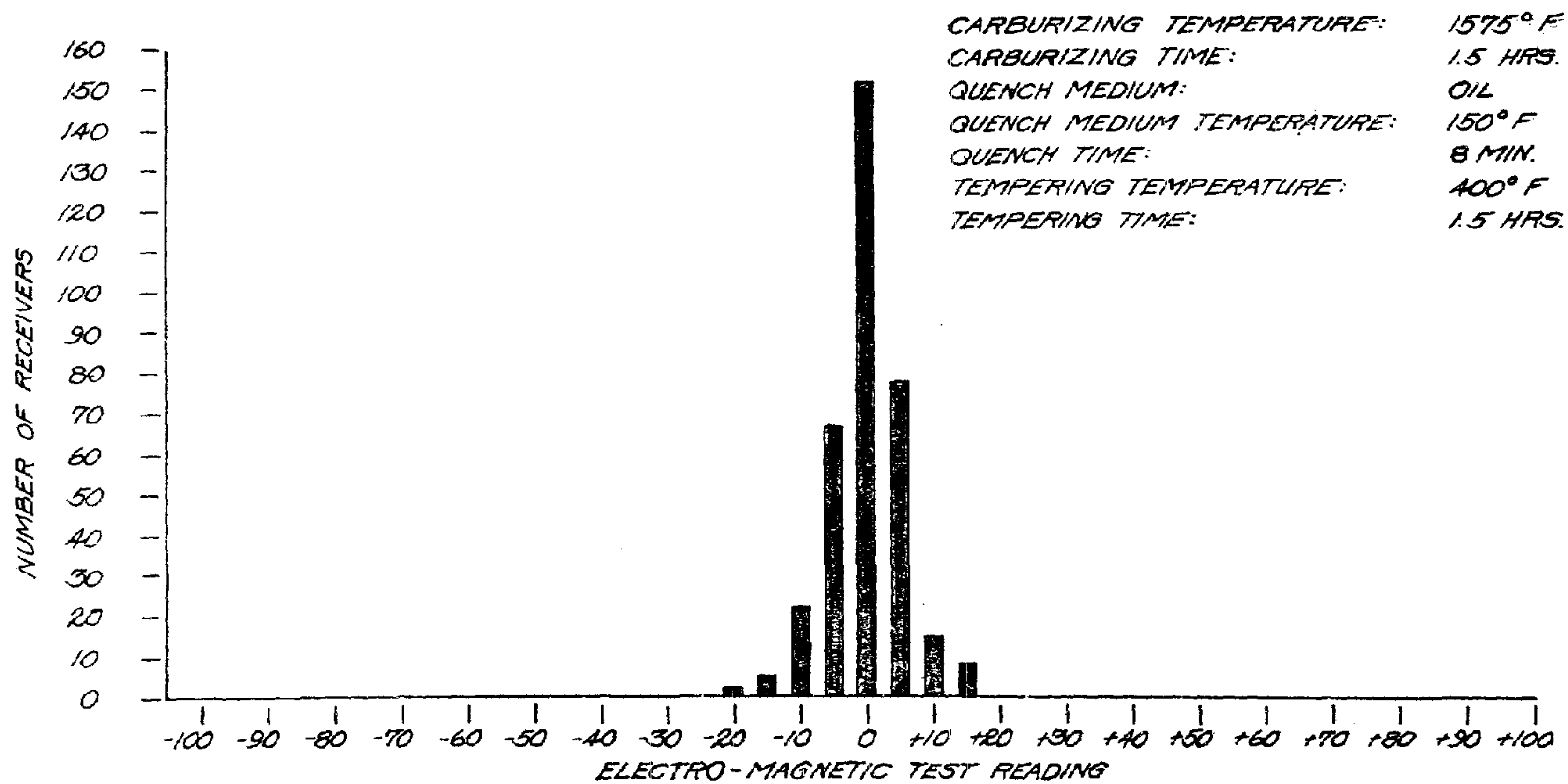
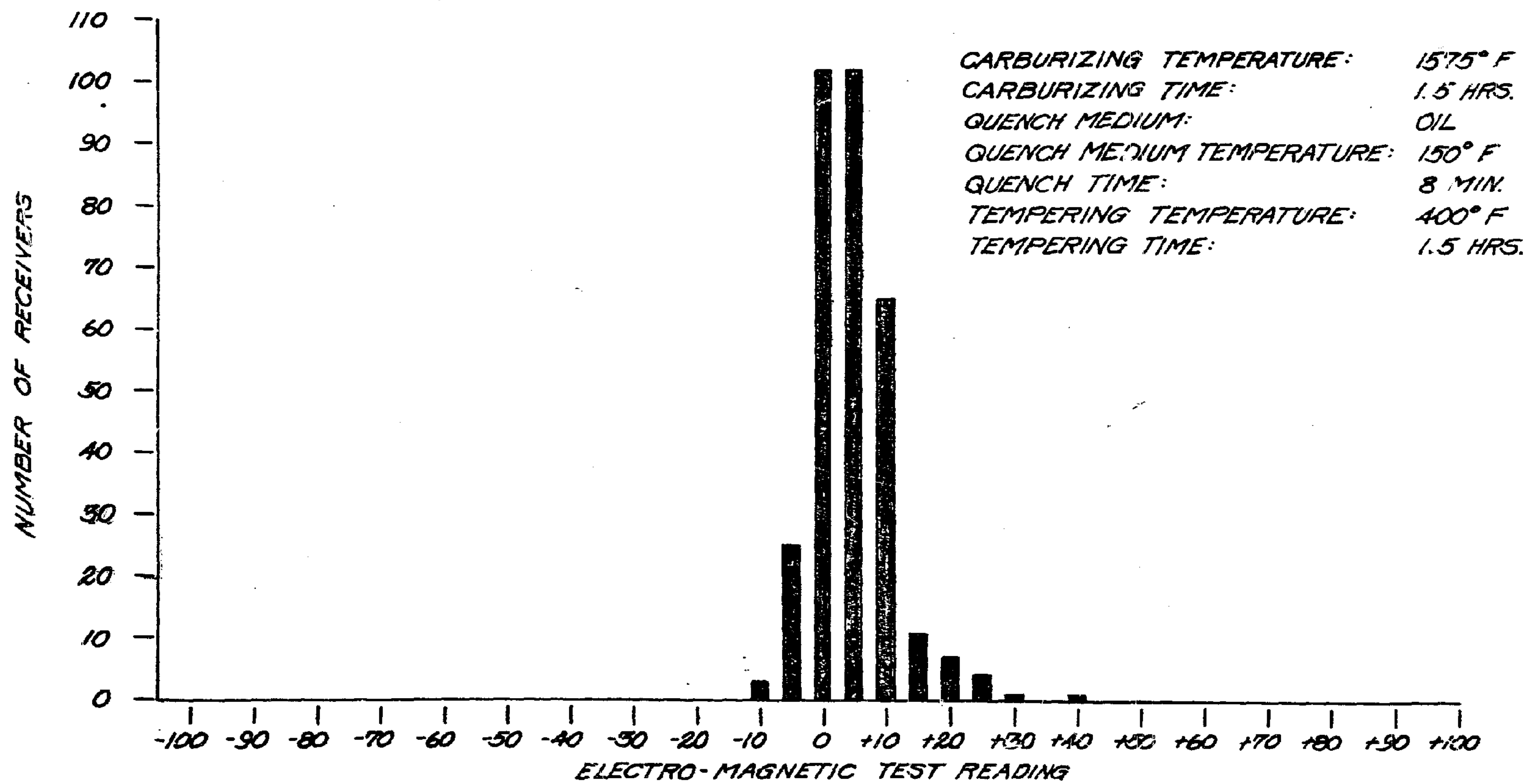


CHART 9 – DISTRIBUTION OF TEST READINGS ON 321 "CODE HG" RECEIVERS FROM HEAT LOT P



2. Distribution Studies "Code HG" Receivers

a. Procedure - Continued

gathered on 3120 receivers from heat lots H, N, O, P and Q at "Code HG". Forty-four of these were selected and metallurgically examined.

b. Results

Distribution data on "Code HG" heat lots H, N, O, P and Q are shown in Charts 5 - 9. Heat lots, O, P, Q and a majority of N had received the same treatment: Carburized at 1575°F for 1-1/2 hours, quenched in oil, agitated and maintained at 150°F, and tempered at 400°F for 1-1/2 hours. Remaining receivers from heat lot N, designated as N^1 for clarity, were given the following treatment: Carburized at 1550°F for 1-1/2 hours, quenched in oil, agitated and maintained at 150°F, and tempered at 415°F for 1-1/2 hours. Heat lot H was given similar treatment with exception that no agitation was used and receivers were tempered at 400°F for 1-1/2 hours. Distribution variations are shown. Readings on receivers in heat lot N ranged from +5 to -60 with peak of distribution at -15. Lots O and P had distribution shift to the right of Lot N with major distribution between 0 and +10. Lot Q distribution shifts negative with respect to N with range -20 to -45; peak distribution, between -25 and -35. Lot N^1 ranged +15 to -75 with peak distribution at -30. Heat lot H had peak distribution at 0. Readings ranged -15 to +32.

Surface and core hardness data on receivers examined are shown in Tables 10-12. Lots H, N, N^1 and Q indicate general tendencies for core hardness to decrease with more negative magnetic reading within each separate heat. Rockwell D and C hardness also tends to decrease, particularly in the ring section. In the thinner section, the rail section, hardness is more uniform.

TABLE 10 - SURFACE AND CORE HARDNESS DATA ON "CODE HG" RECEIVERS FROM HEAT LOTS H AND N'

RECEIVER NO.	HEAT LOT	M A READING	CORE HARDNESS Rc G AREA	SURFACE HARDNESS			
				RAIL		RING	
				R_D	R_C	R_D	R_C
364369	H	+32	41.5-41.5 41	68.5-68 68-67.5	56.5-56 55-55	66.5-66 65.5-64.5	52-51.5 51.5-51.5
364375	H	+20	33-33 33.5	69-68.5 68.5-68	56-55.5 55-55	69.5-69 68-67.5	54-54 53.5-53.5
364400	H	+5	36.5-36 35.5	68.5-68 67.5-66.5	53-53 53-52.5	66-65 65-63.5	51.5-51 51-50.5
364447	H	+5	35-35 34	67.5-67 66.5-66.5	53.5-53 53-53	67-66.5 66.5-66	52-51 50.5-50.5
364444	H	-5	30.5-30 30	66.5-66.5 66-65.5	53.5-53.5 52.5-52	65.5-64.5 64.5-63.5	49.5-48.5 48-47.5
275428	N'	0	39.8	69-68.5 68-68	55-55 55-54.5	65-64.5 64.5-64	49-48.5 47.5-47.5
275479	N'	-5	37.8	68.5-67.5 67-67	54-53.5 53.5-53.5	63-63 62-62	45.5-45.5 45-45
275450	N'	-10	30.2	67-67 66.5-66.5	53.5-53 52.5-52	65-64.5 64-64	48-47.5 47.5-46.5
275460	N'	-15	31.6	66.5-66.5 66-66	53-52.5 52-52	64.5-64 63.5-62.5	47.5-47.5 47-45.5
275194	N'	-25	32.8	67.5-67 66.5-66.5	53-53 53-52	63-62.5 62-61.5	47-47 45-44.5
275343	N'	-27	38.0	66.5-66 65.5-65.5	52-52 51.5-51	63.5-62 62-62	47-46.5 46-45.5
275410	N'	-30	35.6	67-66.5 66-65.5	52.5-51.5 51-51	63-63 62.5-62.5	46.5-46.5 46-45.5
275397	N'	-30	31.5	66.5-66 66-65.5	52-52 51-50.5	64-63.5 63.5-63	47-46.5 46.5-46
294918	N'	-50	32.2	65.5-65.5 65-64.5	51.5-51 50.5-50	59-59 57.5-57	42-42-41 38.5-37.5
275109	N'	-55	26.5	67-66.5 66-66	53-52 52-51.5	62-62 61.5-60	45.5-45 45-44.5
275234	N'	-65	28.0	64.5-64.5 64-63	50-49 48.5-47.5	59.5-58.5 58.5-58	42-42 41-41

TABLE 11 - SURFACE AND CORE HARDNESS DATA ON "CODE HG" RECEIVERS FROM HEAT LOTS N AND Q

RECEIVER NO	HEAT LOT	MA READING	CORE HARDNESS Rc G AREA	SURFACE HARDNESS			
				RAIL		RING	
				RD	Rc	RD	Rc
365950	N	0	36.5-36-36	68.5-68.6 68-67.5	55-55 55-54.5	66.5-66.5 65.5-65	49.5-49 48.5-48.5
365030	N	-12	32-31.5-31	68-67.5 67.5-67	54-54 53.5-53	66-65.5 65.5-65	51-50.5 49.5-49
365358	N	-10	38-36.5-36	67-66.5 66-66	53.5-53.5 53.5-53	63.5-63.5 63-62.5	48.5-47.5 47.5-46.5
364930	N	-15	36-35.5-35	68.5-68.5 68-67.5	55-54.5 54.5-54.5	64.5-64 64-64	48-47.5 47.5-46.5
365592	N	-25	33.5-33-32.5	67.5-67 67-66.5	54-54 53.5-53.5	64.5-64 64-63.5	48-47.5 47-46.5
365899	N	-30	29-28-28	68.5-68 67.5-67.5	55-54 54-53.5	64-63.5 63.5-63	47-46.5 46-45.5
365670	N	-37	31.5-31-30	67.5-67 67-66.5	53.5-53 53-53	63-63 63-62.5	46.5-46 45.5-45.5
369131	Q	-18	32-31.5	69-69 68.5-68	56-55.5-55.5 55-53.5	67-66 65.5-65.5	49.5-48.5 48-48
369136	Q	-21	36-36	69.5-69 68.5-68	56-56 55-54.5	67.5-66 66-65.5	50.5-50.5 50-49.5
369628	Q	-27	33-32.5	69-68 67-66.5	54.5-54 54-53.5	65-64.5 64-63.5	46.5-46 45.5-45.5
369640	Q	-31	32.5-32	69.5-67.5 67.5-67.5	55.5-55 55-54	66.5-66 65.5-65	49.5-49 48-47.5
369670	Q	-41	28-27	68-67.5 67-66.5	55-54.5 53-53	64.5-63.5 63.5-63.5	47-46 45-45

TABLE 12 – SURFACE AND CORE HARDNESS DATA ON "CODE HG" RECEIVERS FROM HEAT LOTS P AND O

RECEIVER NO.	HEAT LOT	MA READING	CORE HARDNESS R_c F & G AREAS	SURFACE HARDNESS			
				RAIL		RING	
				R_D	R_c	R_D	R_c
368351	P	+41	30-31	69-69 68.5-68	55.5-54.5-53.5 53.5-52.5	65-65 64.5-63.5	47-47 46.5-46
368358	P	+35	31.5-31.5	69-68.5 68-67	55-54 54-54	66-64.5 64.5-63.5	48-47 46.5-46
368357	P	+20	31-31	68-68 67.5-67.5	52-51 51-50	65-64.5 64-63.5	48-47.5 46-45.5
368308	P	+7	32-32	69-68 68-67	55.5-55 54.5-54	65.5-65.5 65.5-68	48-48 46.5-46
368915	P	0	26.5-27.5	68.5-68 67.5-67.5	55-54 54-53	65.5-65.5 65-64	48-48 48-47
369041	P	0	30-29	68-66.5 66.5-66.5	53-53 52.5-52	64-64 63.5-62.5	45.5-45.5 45-44.5
369006	P	-10	27.5-26	68.5-67.5 67-67	54-53 53-52	65.5-65.5 65-65	48-47 47-46.5
367564	O	+18	30.5-32.5	69.5-69.5 69-68.5	57-56.5 56.5-56	68.5-68.5 67.5-67	52-51.5 51.5-51.5
368382	O	+5	32.5-29	69-69 68.5-68.5	56.5-56 56-55.5	69-68 68-67.5	51-50.5 50.5-50
368144	O	+3	29-32.5	69-69 68.5-68	56-55.5 55.5-55.5	66-66 65.5-66	49-49 48.5-48.5
368546	O	-6	36-34	68.5-68 68-67.5	54.5-54.5 54-54	68-67.5 67-66.5	51.5-51.5 51-50.5
368121	O	-9	31-29	69-68.5 67.5-67.5	55-54.5 54-53.5	67-66.5 66.5-66.5	49.5-49 49-48
368553	O	-10	34-29	69-68.5 68-66.5	55-54.5 54.5-54.5	67-66.5 66.5-66	49-49 48.5-48

2. Distribution Studies "Code HG" Receivers

b. Results - Continued

Core hardness data on Lots P and O are at or below the specification minimum in F-G sections. Rockwell D and C values were fairly constant and core hardness did not vary widely over the range of magnetic readings.

Receivers from heat lots investigated were forged at two sources: "Code SB" and "Code LR". Heat lots H, N, and Q, were forged at "Code SB"; heat lots O and P, at "Code LR". Observation may be important because distribution and hardness data of lots O and P differed from data obtained on heat lots H, N, and Q. The latter indicated general tendencies of correlation in magnetic data with core hardness; whereas, the former appears to offer less correlation. Also, the distribution curves for lots O and P were more compact and heat lots H, N, and Q more widespread. When data are tabulated as in Tables 13 and 14 according to forging source, each group shows tendencies of decreasing core hardness with more negative magnetic reading. When data in groups are combined, no tendency is indicated.

Table 13

Data on Heat Lots from Forging Source "Code SB"

Heat Lot	Magnetic Analysis Reading	Core Hardness (Rc)
H	+32	41.5
H	+20	33.5
H	+ 5	36
H	+ 5	35
N[1]	0	40
N	0	36
H	- 5	30.5
N[1]	- 5	38
N[1]	-10	30
N	-10	37.5
N	-12	32
N	-15	36
N	-15	32
Q	-18	32
Q	-21	36
N[1]	-25	33
N	-25	33
N[1]	-27	38
Q	-27	33
N[1]	-30	35.5
N[1]	-30	31.5
N	-30	29
Q	-31	32

2. Distribution Studies "Code HG" Receivers

Table 13 (Continued)

Heat Lot	Magnetic Analysis Reading	Core Hardness (Rc)
N	-37	31
Q	-41	27.5
N[1]	-50	32
N[1]	-55	26.5
N[1]	-65	28

Table 14

Data on Heat Lots from Forging Source "Code LR"

Heat Lot	Magnetic Analysis Reading	Core Hardness (Rc)
P	+41	31
P	+35	31.5
P	+20	31
O	+18	32.5
P	+ 7	32
O	+ 5	29
O	+ 3	32.5
P	0	27.5
P	0	29
O	- 6	34
O	- 9	29
O	-10	29
P	-10	26

Table 15 lists hardenability and Table 16 chemical data of heat lots as per supplier certification. No major differences are apparent, although heat lots H and N indicate highest hardenability in the 3/16 to 4/16 inch sections.

2. Distribution Studies "Code HG" Receivers

Table 15

Hardenability of Heat Lots at "Code HG"

Heat Lot	1	2	3	4	5	6	7	8	10	12
H	44	43	40	35	30	27	25	24	23	20
N(N[1])	46	45	40	35	30	29	27	25	24	22
Q	43	41		30		26		23	22	21
O	44	42	36	31	28	25	24	23	21	20
P	43	43	37	33	29	26	25	24	21	21
Specified	48/41	47/37	44/32	41/27	37/23	34/21	32/	30/	28/	26/

Table 16

Chemical Constituents of Heat Lots at "Code HG"

Heat Lot	C	Mn	P	S	Si	Ni	Cr	Mo
H	.20	.80	.014	.049	.32	.58	.54	.21
N(N[1])	.19	.85	.010	.040	.27	.49	.53	.20
Q	.20	.85	.018	.045	.24	.48	.56	.17
O	.20	.80	.015	.042	.25	.51	.57	.19
P	.19	.78	.012	.043	.27	.49	.51	.18
Specified	.17/.23	.60/.95	.04 Max	.035/.050	.20/.35	.35/.75	.35/.65	.15/.25

Destructive examinations conducted during the period of 25 July to 16 August at "Code HG" on receivers processed from each salt pot indicate that receivers in Lots H and N had highest core hardness; lots O and Q, medium core hardness; and lot P, the lowest core hardness. Destructive results indicated relatively good uniformity for core hardness within individual heat lots.

3. Distribution Studies Springfield Armory Receivers

a. Procedure

At Springfield Armory, distribution data were obtained periodically on receivers manufactured from different heat lots in process. Distributions were made on the following lots: 90969, 91044, 90833, 82458, 82323, and 64761. A total of 3,263 receivers was tested.

3. Distribution Studies Springfield Armory Receivers - Continued

b. Results

Distribution data on Springfield Armory heat lots studied are shown in Charts 10 - 15. Table 17 lists the number of receivers tested, the range of magnetic readings and the peak distribution.

Table 17

Distribution Data Springfield Armory Receivers

Heat Lot	Number Tested	Range Magnetic Readings	Distribution Peak
90969	1641	+35 to -85	0 to -10
82458	575	+ 5 to -70	-25
82323	546	+15 to -50	-20
90833	229	+10 to -45	-25
64761	142	+20 to -45	0
91044	93	-10 to -60	-30

Forty-seven receivers from heats 90969, 90833 and 64761 were selected and metallurgically examined. Magnetic and hardness data are shown in Tables 18 - 20. Core hardness in the F and G areas shows partial correlation with magnetic comparator data. Hardness in the lug sections are quite uniform, near the low and mid of the specification requirements for most part. Re-examination of three receivers identified as 107548, 112488 and 110167 in heat lot 90804, which fell within -40 to +40 range but had low core hardness, indicated that receivers were partially magnetized. It was not possible to demagnetize receivers and reread magnetic readings because receivers had already been sectioned. Rockwell C and D data taken on the rail and the ring sections were consistent within each section. Microstructure case depth and chemical data compiled on heat lots 90969 and 90833 are shown in Tables 21 - 22.

CHART 10 — DISTRIBUTION OF TEST READINGS ON 16A1 S.A. RECEIVERS FROM HEAT LOT 90969

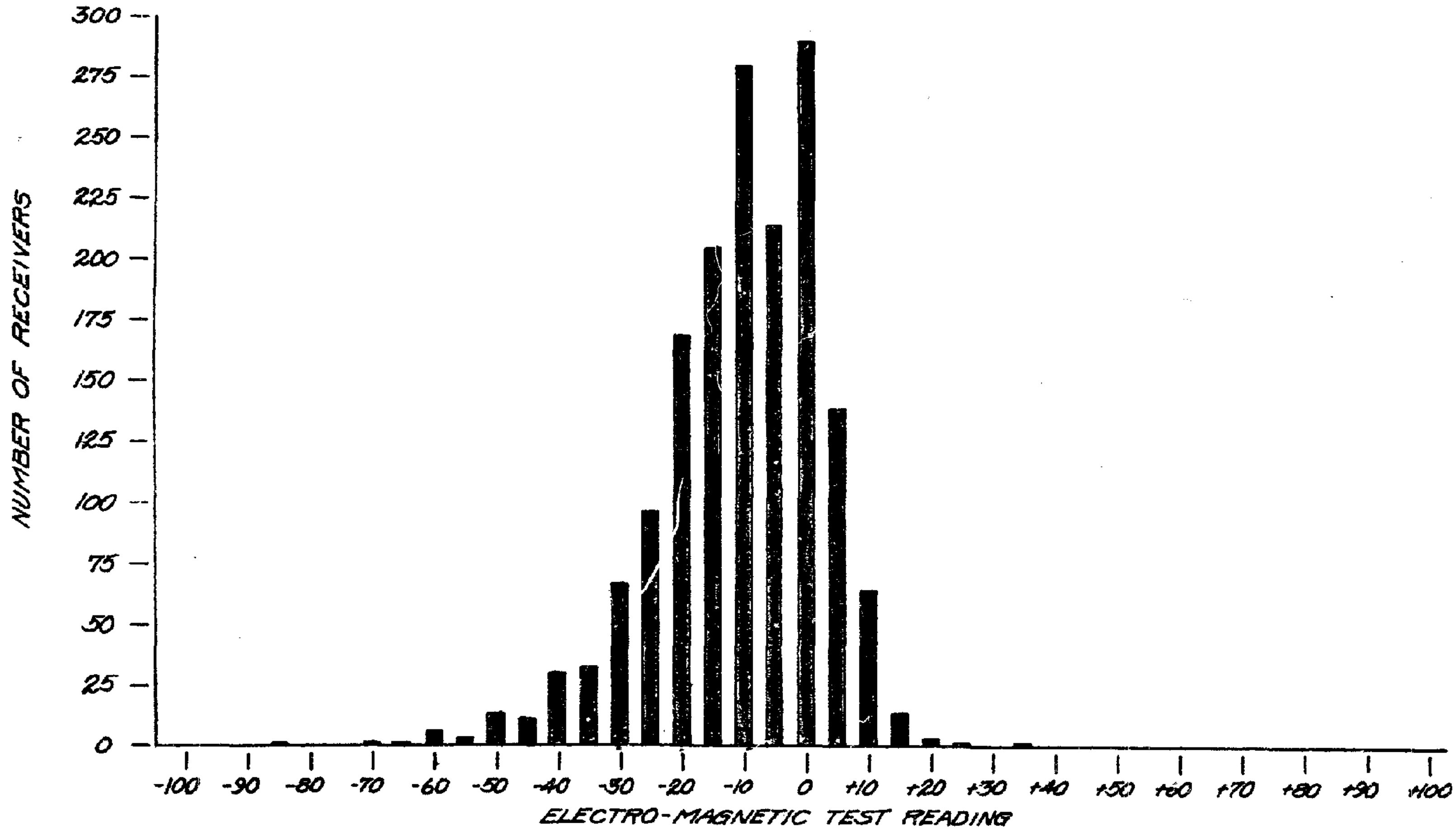


CHART 11 - DISTRIBUTION OF TEST READINGS ON 575 S.A. RECEIVERS FROM HEAT LOT 82A58

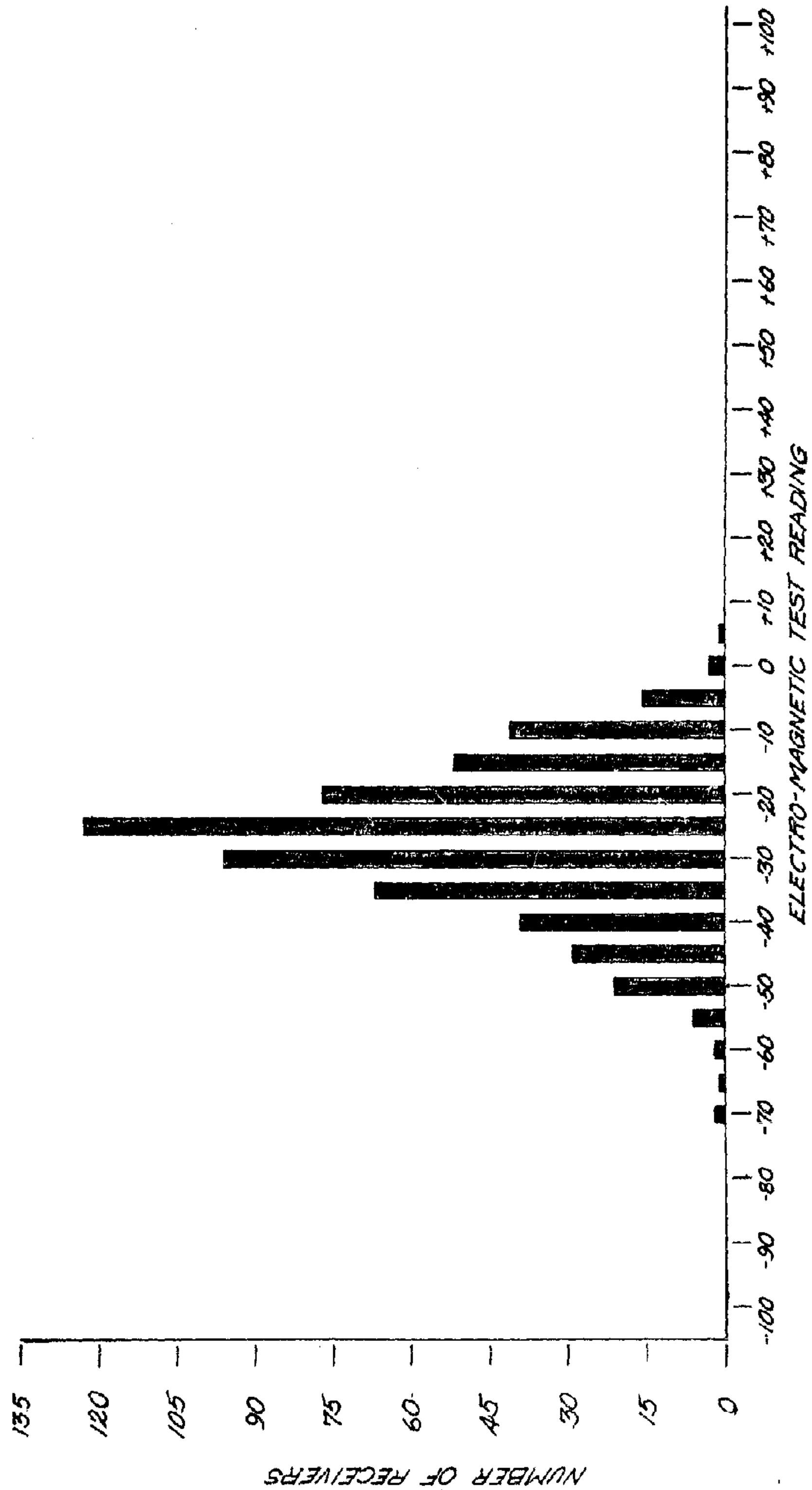


CHART 12 - DISTRIBUTION OF TEST READINGS ON 546 S.A. RECEIVERS FROM HEAT LOT 82323

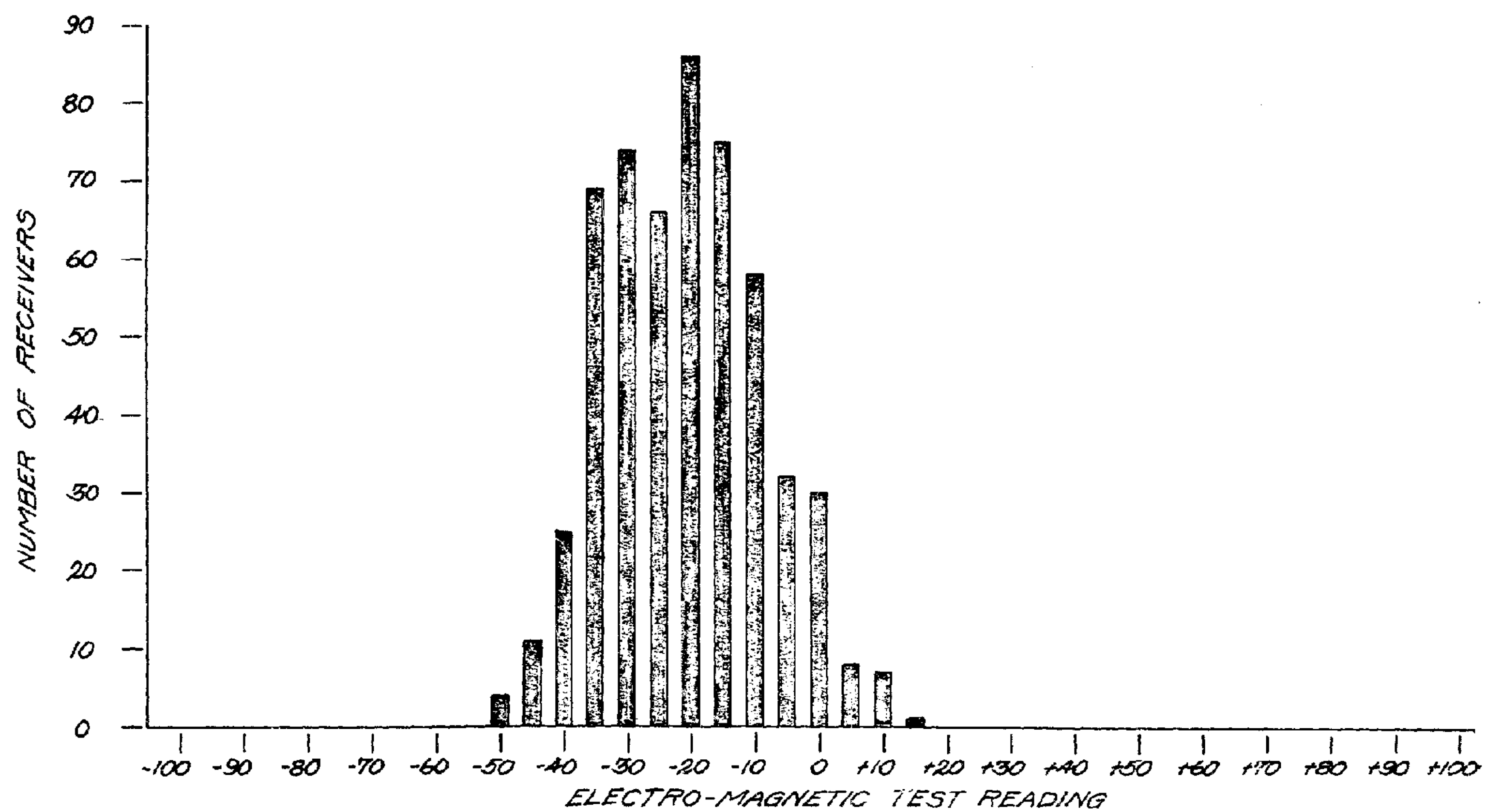
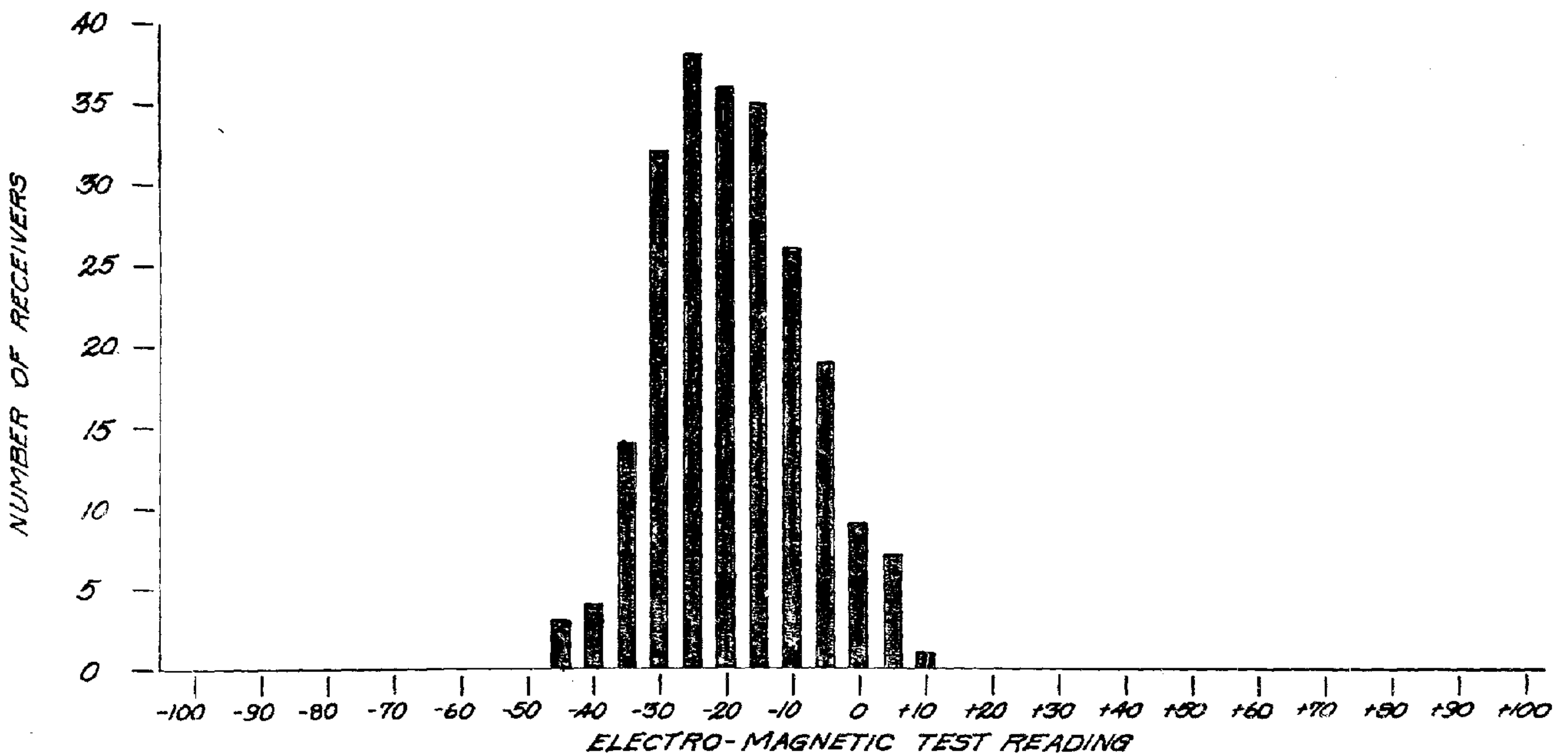


CHART 13 - DISTRIBUTION OF TEST READINGS ON 229 S.A. RECEIVERS FROM HEAT LOT 90833



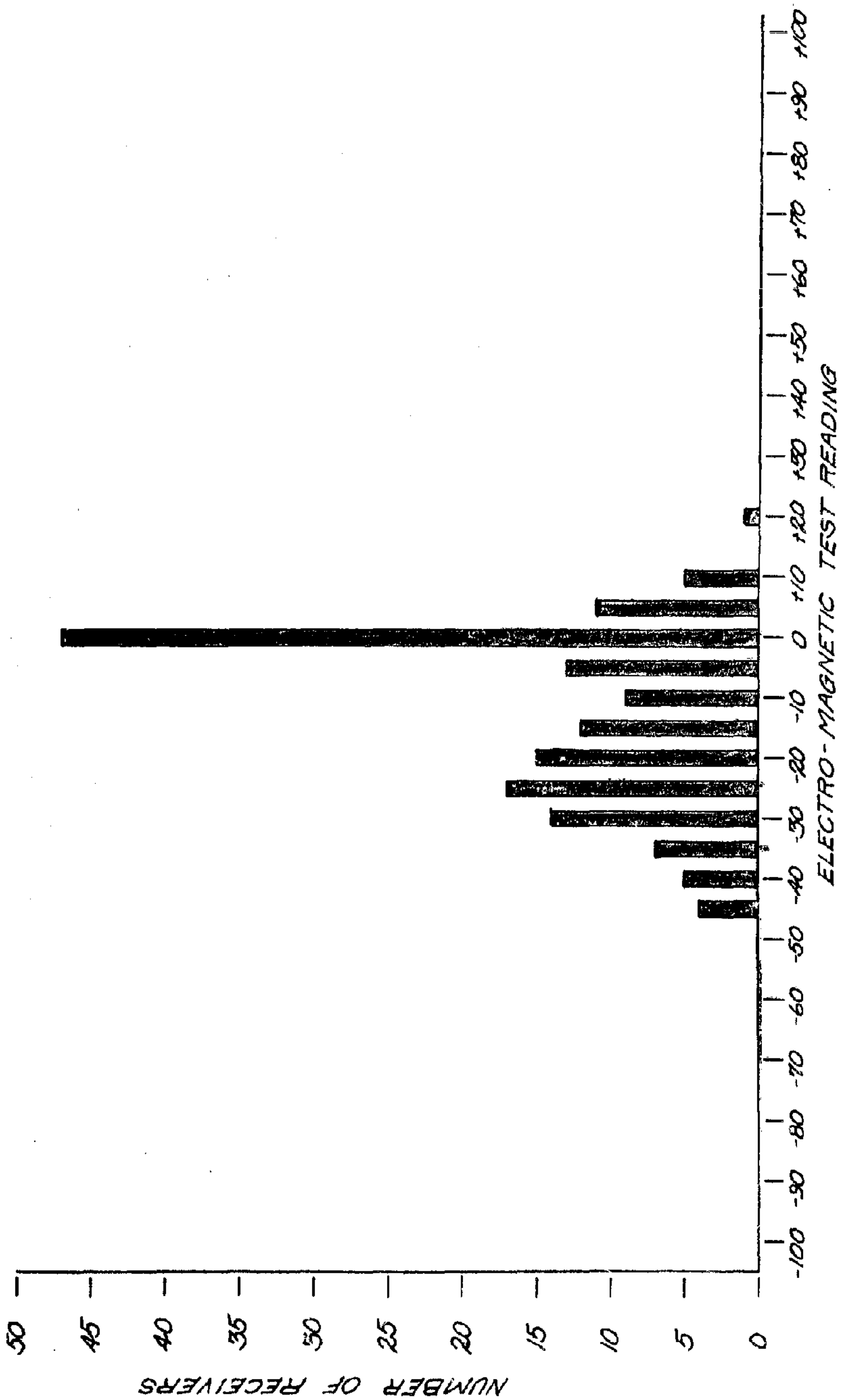


CHART 14 - DISTRIBUTION OF TEST READINGS ON 142 S.A. RECEIVERS FROM HEAT LOT 64T61

CHART 15 -DISTRIBUTION OF TEST READINGS ON 95 SA RECEIVERS FROM HEAT LOT 9104

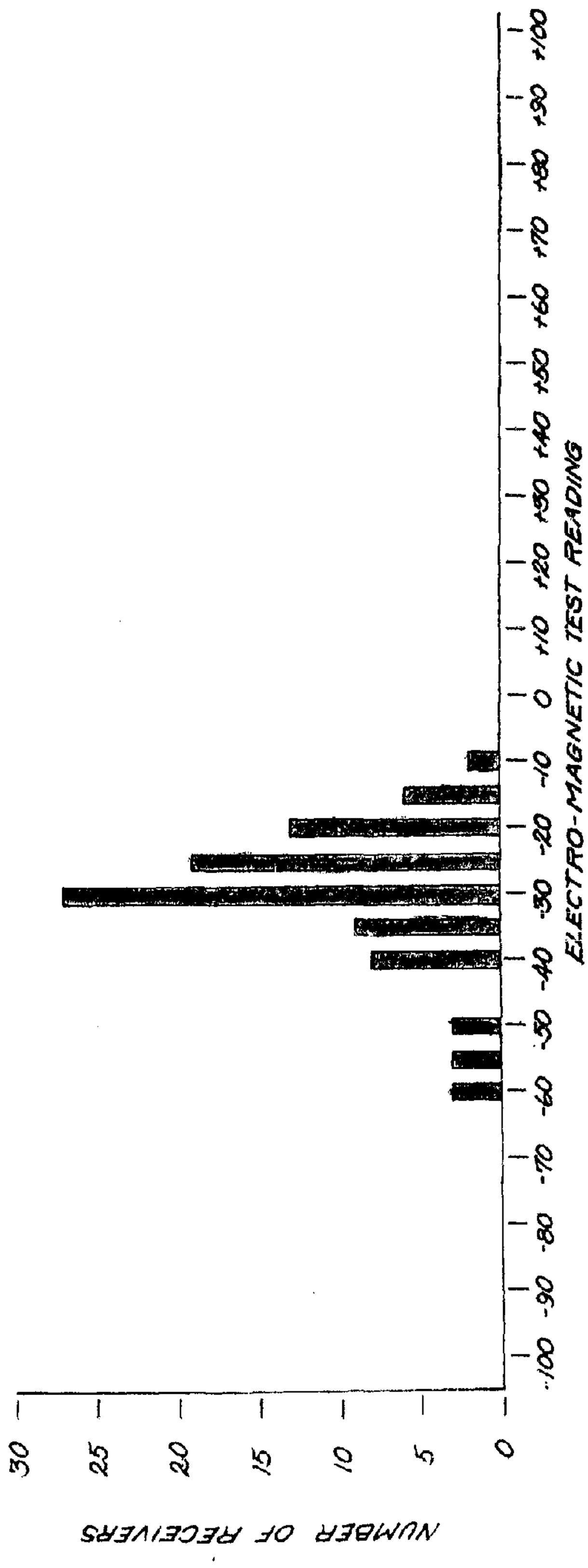


TABLE 18 MAGNETIC AND HARDNESS DATA ON SPRINGFIELD ARMORY RECEIVERS FROM HEAT LOT 90969

RECEIVER NO.	M A READING	SURFACE HARDNESS				CORE HARDNESS (Rc)									
		RAIL		RING											
		RD	Rc	RD	Rc	A	B	C	D	E	F	G	H	I	J
113626	+22	68.5-70.5	55.5-57	65.5-68.5	48.5-51	30.5	30.5	29	31.5	41.5	35	33.5	45	42	43.5
107548	+15	68.5-70.5	54-57.5	62-63	46-46.5	23.6	21.7	22.2	22	22.8	31.4	29	41.9	40.8	43.9
114169	+5	70-71	54-57.5	66.5-68	53-55	33	32	30	33	43.5	37.5	35.5-36	42	45	45.5
113558	+2	68.5-69.5	54-55	65-67	52-53	31	29	29	29	29	37	34	41	43.5	43.5
113148	0	67.5-68.5	50-53.5	60-62.5	42.5-46	26	21.4	21.3	22	23	32.5	31	42.8	39.5	43.2
115543	0	67.5-70.5	50.5-52	61-63.5	48-49	29.5	26.5	26.5	23.5	40.5	35.5	34	44.5	42.5	44.5
115992	-3	67-69.5	53.5-55	64-66	49.5-50.5	30.5	28	27.5	29	37.5	39	34.5-36	43	42	44
112488	-5	67-68	54-54.5	63-66	48-51.5	28.3	27.3	27.8	26.6	28	27.3	29.2	39.2	40.3	41.6
110167	-9	67.5-69	54-55	61-63	45.5-47	26.5	25.5	26	29	40.5	32.5	28.5-30.5	40.5	42.5	44.5
113998	-10	66-68	51-54	64-65	48-51	29.2	28.2	27	32.2	28.3	30	33.8	39.5	41.8	42.4
115738	-13	67-68.5	56-57	61.5-63	45.5-48	31	30.5	30	32	43	33.5	35.5	44	45	45
115231	-18	66.5-68	51.5-54.5	66-66.5	51-52	33.5	29	29.5	33	42	35.5	34-35	44	42	44.5
115480	-20	66-67	51.5-53	63.5-65	49-50.5	32	28	25	27.5	28.5	35.5	30.5-32.1	43.5	42	44
115536	-26	67.5-70.5	53.5-57	64.5-66	49.5-51	30.5	29	27.5	28	40	36.5	31.5-33	42.5	41	44
115096	-27	66-68	51.5-55	65.5	48.5-49	31	30	31.5	31.5	39.5	33.5	35.5	43.5	43.5	44.5

TABLE 19 MAGNETIC AND HARDNESS DATA ON SPRINGFIELD ARMORY RECEIVERS FROM HEAT LOT 90833

RECEIVER NO.	M.A. READING	SURFACE HARDNESS				CORE HARDNESS (R_C)									
		RAIL		RING											
		R_D	R_C	R_D	R_C	A	B	C	D	E	F	G	H	I	J
112357	+10	67-69	53-54	65.5-67 (63)	47-51	25.5-26	23	23-23.5	26-28	34-38	28.5-31	27-29	36-38.5	36.5-38.5	39-40.5
116080	-2	67-69	52.5-55.5	66-67	51-53	31	29	27.5-28.5	28.5	35-36	33.5-35	34-36	38-38.5	42-42.5	41-42.5
114060	-4	65.5-68.5	53-54	60-63.5	42.5-45.5 (46)	24.5-25	25.5	24.5-25	28.5-29	32.5-33.5	31-32	31.5-32	39-41.5	37-40	41-42.5
113583	-4	68-70	54.5-55	64-66	51-53.5	26.5-27	24.5	26-26.5	27	32-34	30-32	30.5-31	41-43	37-37.5	40.5-43
112589	-10	66.5-67	52-54	65-65.5	49-50	29.5-30.5	26-27.5 28	25-26.5	24-26-27	32.5-34 37	35-36	32	40.5-43 44	35-36.5	42-44
112195	-10	68-68.5	54-54.5	65.5-66.5	49-50	26-26.5	22-23	23	23.5-25	33-34-37	32	29-30.5	37.5-42 42.5	35.5-36.5	41.5-43
112646	-15	67.5-68	52.5-54	63-63.5 (60)	45.5-48	28.5-29	27-27.5	27	29.5-30	42.5-43	33.5-34	34-34.5	42-44	43-44.5	44-46
115483	-15	67-69	53.5-55	65-65.5 (62)	49-50	29.5-30	27-28.5	28.5	31-31.5	38	33.5	35-36	41-43	41.5-42.5	43.5-45
114527	-20	67-68	50.5-54	64.5-66	47-49.5	30.5-31	29-29.5	30	23.5-24.5	20.5-21.5	31-31.5	34	39-41	39.5-40	39.5-41
114777	-22	66.5-67.5	53-54.5	60-63	42.5-45	29	27.5-28	27.5	29.5-30	32-33.5	33.5-34.5	33-34	41.5-44	41-42.5	42-43.5
115628	-23	67.5-68	53-54.5	63-64	44.5-45.5	27	27	27.5-28	27-27.5	25-26	35	33.5-35 36	41-43 44.5	39-41-41	42-44
114570	-25	66	52-52.5	62-63	47-52	29-30	28	28-29	29.5-30	39-32.5	32.5-33	34	40-41	40.5-43	42.5-43.5
110708	-25	65.5-68	52.5-54	62.5-63	44-45.5	26-27	27.5-28	27	29.5-30	37-39	32-32.5	32	36.5-40 41	41-41.5	41.5-42.5
115191	-30	67-68	52.5-55	64-67	45.5-46.5 (49)	26.5	24-25	24-24.5	29.5-31	40.5-41	34	29-30.5	38.5-42	41.5-42	44

TABLE 20 . MAGNETIC AND HARDNESS DATA ON SPRINGFIELD ARMORY RECEIVERS FROM HEAT LOT 64761

RECEIVER NO.	M A READING	SURFACE HARDNESS				CORE HARDNESS (R_c)									
		RAIL		RING											
		R_D	R_c	R_D	R_c	A	B	C	D	E	F	G	H	I	J
119188	-2	65-67.5	52-55	65.5-67	51-52	32	29.5-31	27-28	31-32	41.5-43	37.5	35.5-36	39.5-42	43.5-44	43-45
112536	-2	67	53-55.5	63.5-66	49-50.5	29.8	29.2	28.4	31.0	29.3	32.0	35.0	42.5	42.0	42.0
119039	-4	66	51-54	62-65.5	47.5-50	30.5-31	26.5-27.5	26-26.5	30.5-32	38.5-41.5	36	31-32.5	41-43.5	38-39	42-43
118583	-4	65.5-69	54-57	64-65.5	47-50	28.2	28.0	26.7	32.5	29.3	35.0	35.5	42.5	43.5	45.0
118545	-7	66.5-67.5	51-52.5	64.5-65	50.5-54	32	30.5-31	28-29	28-28.5	33-35	37-38	34-36	41.5-43.5	39-40	37.5-39
117609	-8	67.5-69.5	52.5-53.5	68-69.5	52-54.5	29.5	25.0	23.8	28.7	27.2	28.5	32.0	43.5	42.5	44.5
119691	-8	66.5-67	52-53.5	59-62.5	45-46.5	28.8	27.8	25.5	32.4	27.5	31.5	32.0	43.0	41.0	38.5
119853	-10	66-67	52.5-54	58-59	47.5-48.5	27.4	25.8	26.0	30.2	26.8	36.0	34.5	43.0	44.0	44.0
119231	-15	65-68.5	54-55	64.5-66	47-49.5	28.0	25.7	24.5	26.2	27.2	33.5	32.5	36.5	40.5	43.5
119575	-16	65.5-66.5	50-52.5	61-63	48-49	25.0	21.8	21.8	25.5	23.3	30.0	30.5	43.5	37.0	41.0
119036	-16	65-66	52-54	57.5-59	49-51	28	26.5-27	28-29	25-25.5	22-23	33-34.5	30.5	34-35.5	36-36.5	42-42.5
117274	-25	66-68	52-55	64-65.5	48-51	27	26-26.5	25-25.5	29-29.5	38.5-40	31-32	30-31.5	38.5-41.5	42-42.5	42-44
118411	-25	67-68.5	51-54.5	64-66	48.5-49	31.7	29.8	29.0	30.8	30.3	35.5	36.0	43.5	43.0	43.0
118405	-30	65-67	53-54	63-63.5	47-49.5	26.5-27	26	26-27	27-30	36-39	33	30.5-31	39-43	36.5-40	42.5-45
118636	-32	65-68	52-54	65-65.5	50-53	29.0	25.7	25.8	26.0	25.0	33.5	33.0	41.0	43.5	42.0
117102	-35	66-67	54-56	66-67	49-50.5	27.4	22.7	25.5	28.4	26.6	31.0	34.5	43.5	43.5	43.0
117004	-36	66-68	52.5-55	61-63	45.5-51	30-31	30-30.5	29-30.5	31-31.5	39.5-40	35.5-36	37-38	42-43	43-44	43-44
116471	-40	66-70	53.5-54.5	63-65.5	48-51.5	30-31	28-29	28-29	31.5-32	39-40	33-35	33.5-35	39-42	43.5-44.5	43-44.5

TABLE 21 MICROSTRUCTURE, CASE DEPTH, AND CHEMICAL DATA ON SPRINGFIELD ARMORY RECEIVERS FROM HEAT LOT 90969

RECEIVER NO.	MICROSTRUCTURE			CASE		CHEMISTRY				
	FERRITE	UPPER BAINITE	MARTENSITE AND LOWER BAINITE	DEPTH (INCHES)	RETAINED AUSTENITE	Cr .35-.65	Si .20-.35	Mn .60-.95	Mo .15-.25	Ni .35-.75
113626	5-10%	35-55%	REM.	.015-.017	50-15% TO .002"	.47	.25	.77	.15	.45
107548						.50	.27	.81	.17	.48
114169	5-10%	40-65%	REM.	.015-.017	TRACES OF 100%	.50	.24	.76	.15	.50
113558	3-7%	25-40%	REM.	.016-.018	40-10% TO .0025"	.51	.26	.76	.17	.48
113148	5-10%	40-60% COARSE & BLOCKY	REM.	.014-.016	15% TO .002"	.49	.29	.86	.17	.48
115543	4-8%	35-55%	REM.	.015-.018	15-5% TO .002"	.50	.26	.78	.17	.47
115992	3-5%	15-30%	REM.	.016-.018	15% TO .002"	.53	.30	.86	.19	.50
112488						.48	.26	.73	.18	.49
110167	5-10%	35-55%	REM.	.014-.016	TRACES TO 5%	.49	.28	.85	.17	.47
113998						.46	.27	.79	.16	.45
115738	6-9%	35-45%	REM.	.014-.016	TRACES OF 100% ON SURFACE. 25-5% TO .003"	.51	.22	.77	.16	.49
115231	5-10%	35-55% COARSE & BLOCKY	REM.	.016-.018	40-15% TO .002"	.49	.27	.79	.16	.46
115480	3-8%	25-40%	REM.	.016-.018	15-5% TO .0015"	.50	.30	.85	.16	.47
115536	4-8%	25-45%	REM.	.016-.018	35-5% TO .004"	.55	.23	.78	.18	.49
115096	5-8%	30-50%	REM.	.014-.016	TRACES OF 100% ON SURFACE 10% TO .001"	.45	.26	.73	.17	.47

TABLE 22 MICROSTRUCTURE, CASE DEPTH, AND CHEMICAL DATA ON SPRINGFIELD ARMORY RECEIVERS FROM HEAT LOT 90833

RECEIVER NO.	MICROSTRUCTURE			CASE		CHEMISTRY				
	FERRITE	UPPER BAINITE	MARTENSITE AND LOWER BAINITE	DEPTH (INCHES)	RETAINED AUSTENITE	Cr .35-.65	Si .20-.35	Mn .60-.95	Mo .15-.25	Ni .35-.75
112357	8-12%	60-75% COARSE & BLOCKY	REM.	.014-.016	TRACES OF 100% 25% TO .002"	.48	.22	.30	.15	.39
116080	5-8%	20-35%	REM.	.014-.016	NONE	.48	.24	.75	.18	.44
114060	3-10%	45-55% COARSE	REM.	.014-.015	TRACES OF 100% ON SURFACE.	.47	.23	.75	.16	.40
113583	5-10%	45-60% FINE TO COARSE	REM.	.015-.017	TRACES OF 100%, UP TO 10% TO .002	.51	.23	.79	.18	.40
112589	5-8%	40-50% FINE TO COARSE	REM.	.013-.015	TRACES ON SURFACE	.49	.24	.80	.18	.45
112195	3-10%	35-45%	REM.	.013-.015	TRACES OF 100%	.49	.24	.75	.18	.40
112646	3-8%	25-40%	REM.	.013-.014	TRACES OF 100% ON SURFACE	.49	.25	.81	.15	.40
115483	3-6%	30-35%	REM.	.015-.016	TRACES OF 100% ON SURFACE	.48	.23	.80	.18	.42
114527	3-10%	35-55% FINE & BLOCKY	REM.	.012-.013	TRACES	.49	.24	.76	.15	.39
114777	8-12%	50-75% COARSE	REM.	.012-.013	60% TO .0005"	.46	.25	.81	.16	.38
115628	3-7%	20-35%	REM.	.014-.016	NONE	.50	.24	.78	.18	.39
114570	3-8%	40-50% FINE TO COARSE	REM.	.012-.014	TRACES	.45	.25	.80	.15	.38
110708	3-7%	25-30% FINE	REM.	.013-.014	TRACES OF 100%	.44	.23	.78	.15	.37
115191	3-7%	25-30% FINE	REM.	.015-.016	100% ON SURFACE 5% TO .0015"	.49	.24	.82	.16	.40

B. Third Harmonic Studies

1. Investigations Conducted

Distribution studies noted above on receivers from all manufacturers were basically measurements employing filtered 60-cycle frequency, termed magnetic comparator test readings. Magnetic tests in addition to these were made in efforts to correlate non-destructive test results with material properties. Studies included investigations of third harmonic (180 cycle) amplitude and phase shift. Data were primarily gathered on "Code HG" receivers from heat lots P, O, and Q and "Code OH" receivers specially treated. Studies were also made on problem of retempered receivers inan attempt to differentiate highly tempered or retempered receivers from those which had low core hardness.

Magnetic comparator equipment in conjunction with a vacuum tube voltmeter and oscilloscope was used in third harmonic measurements. The portion of the wave form investigated was set by the index of the comparator instrument. Coils were set in relatively the same position because changes in amplitude and phase were noted if arranged oppositely; 60 cps and 180 cps data were initially obtained separately. In this investigation the 60 cps data setup was changed in order to have readings of all receivers on scale. Subsequently, through use of a 180 cps band filter and circuit shown in Figure 10, all data were obtained in one measurement. The ratio of 60 cps to 180 cps amplitude was calculated.

2. Results

Data on 60 cps measurements, 180 cps measurements, ratio of 60 cps/180 cps, and core hardness in F and G receiver areas on "Code HG" receivers in heat lots P, O, Q, and on "Code OH" Series 1 and 2 are shown in Tables 23 and 24.

B. Third Harmonic Studies - Continued

Table 23
Third Harmonic Data "Code HG" Receivers

Receiver Identity	Heat Lot	60 cps	180 cps	Ratio 60 cps/180 cps	Core Hardness F	Core Hardness G
368351	P	1.16	.01275	$.93 \times 10^2$	29.5	31
368358		1.19	.0136	.885	31.5	31.5
368357		1.29	.0141	.92	31	31
368308		37	.0141	.975	32	32
368915		40	.0145	.98	26.5	27.5
369041		40	.0145	.98	30	29
369006		45	.01465	1.0	27.5	26
367564	O	30	.0139	.935	30.5	32.5
368382		37.5	.0148	.93	32.5	29
368144		39	.0148	.94	29	32.5
368546		43	.0146	.95	36	34
368121		45	.0148	.98	31	29
368553		45	.0148	.985	34	29
369131	Q	49	.0165	.90	32.5	32
369136		51	.0162	.93	35	36
369628		53	.01645	.93	34	33
369640		55	.0162	.955	35.5	32
369670		60	.0171	.935	31	27.5

B. Third Harmonic Studies - Continued

Table 24
Third Harmonic Data "Code OG" Receivers

Receiver Identity	Group	60 cps	180 cps	Ratio 60 cps/180 cps	Core Hardness F	Core Hardness G
Series 1 - 40600	O	1.27	.0148	$.855 \times 10^2$	41	42
35034		35	.0158	.855	43.5	46
40701		26	.0142	.89	43	45
38630	I	39	.0155	.90	38	36.5
35428		32	.0152	.87	40	43.5
34980		30	.0150	.87	37.5	36.5
40356	U	55	.0162	.955	27	26
Series 2 - 35899	O	40	.0151	.925	40.5	42
40994		34	.0147	.91	42	44.5
35662		34	.0147	.91	41	37
40876	I	38	.0148	.93	39.5	38
35688		30	.0143	.91	41	35.5
39782		40	.0149	.94	38.5	35.5
35716	U	56	.0160	.975	28	25.5
35424		70	.0148	1.15	26	28

Results indicate a tendency for third harmonic amplitude to increase with a decrease in core hardness within individual lots or groups from each contractor. Correlation of ratio of first to third harmonic with core hardness is better than the correlation core hardness with either first or third alone. Highest ratios were obtained on receivers with lowest core hardness. When data from different heats and from contractors are combined, no direct correlation with core hardness is apparent. Identical ratios have widely different core hardness in many instances.

B. Third Harmonic Studies - Continued

"Code OH" receivers which had been previously tempered at 425°F for 1 hour were retempered at 475°F for 1 hour and tested by use of 60 cps and 180 cps measurements. Table 25 shows the results on measurements before and after retempering.

Table 25

Third Harmonic Data on Retempered Receivers

Receiver	Before Retemper			After Retemper		
Identity	60 cps	180 cps	Ratio 60/180	60 cps	180 cps	Ratio 60/180
30513	1.29	.0145	$.89 \times 10^2$	1.76	.0192	$.93 \times 10^2$
31225	1.43	.0156	.92	1.84	.0195	.94
31554	40	.0150	.935	84	.0191	.965
30899	32	.0150	.88	75	.0197	.89
32682	35	.0153	.885	79	.0205	.875
25705	42	.0149	.955	82	.0188	.965
40623	54	.0152	1.01	90	.0190	1.0
41231	52	.0155	.98	90	.0197	.965

It is seen that both the 60 cps and the 180 cps measurements are noticeably affected by retempering at a higher temperature; however, the ratio was not appreciably affected. The ratio of 60 cps to 180 cps makes it possible to estimate the core condition irrespective of whether attempts have been made to alter magnetic readings by retempering, local heating, or use of excessive tempering temperatures.

III. Mechanical Hardness Tests for Core Hardness Evaluation

Until this investigation, little success had been reported by several investigators in correlating core hardness with surface hardness measurements on a case hardened steel such as that being used in the M14 receiver. At Springfield Armory, similar results were indicated in preliminary tests. Initial plots of superficial surface measurements versus core hardness indicated no significant correlation. Rockwell C surface measurements, influenced in some degree by the core due to penetration depth, plotted versus core hardness showed only slight correlation with extremely wide scatter.

III. Mechanical Hardness Tests for Core Hardness Evaluation - Continued

However, in plots of surface hardness measurements versus magnetic readings previously described, the variations in surface hardness measurements between two different loads 100 kg and 150 kg (Rockwell D and C), and between areas of different section size appeared to vary in some relation to core hardness. As a result, many different combinations of data were studied to determine whether a valid method could be developed for prediction of core hardness from surface measurements.

Several efforts were made to correlate the data previously accumulated on a large number of receivers. Charts were made listing Rockwell D and C surface hardness, Rockwell C core hardness, magnetic test readings, and metallurgical examinations of the core structure. Surface hardnesses were measured on the rail of the receiver (a thin section) and on the front ring (a heavier section about one inch in front of the lug area). Hardness measurements were taken in these sections because of convenience of flat, parallel surfaces. Such surfaces are required for proper measurements. Core data, however, were taken in the lug section because structure in this area is critical to weapon function.

One of the first combinations which showed promise was a three-way plot of surface Rockwell C hardness on the rail, surface Rockwell C hardness on the ring, and core Rockwell C hardness in the lug area. Measurements were recorded for 161 receivers fabricated from several different heat lots from "Code OH," Code HG," and Springfield Armory. Hardness data on these receivers were plotted, and results of each receiver studied in relation to the graph developed. Graph showed fairly accurate correlation as indicated by the following results:

134 had core hardness	within ± 2 Rc of that predicted	- 83.5% accurate
150	within ± 3 Rc of that predicted	- 93.5% accurate
157	within ± 4 Rc of that predicted	- 97.5% accurate
161	within ± 5 Rc of that predicted	- 100% accurate

Because hardness in any receiver section decreases from the surface into the core and the slope of this hardness versus depth varies with hardenability and quenching rate, it was felt that this slope should be determined. Measurements were made of surface hardness in one area with the use of two different loads and, therefore, two penetration depths - namely, Rockwell D (100 kg) and Rockwell C (150 kg) to accomplish this end. Rockwell D and C hardness measurements previously recorded on the ring of the receiver were plotted on a three-way graph versus core hardness in the lug area. Results were most encouraging:

Predicted core hardness	within ± 2 Rc	- 89%
	within ± 3 Rc	- 97%
	within ± 4 Rc	- 100%

III. Mechanical Hardness Tests for Core Hardness Evaluation - Continued

A mathematical interpretation of the plot from these preliminary data takes the following form:

Core Hardness = 2 (Rc + k - R_D) where Rc and R_D are surface hardness measurements. From the various combinations of plotting the available data, the factor k apparently depends on section size of the area in question and may vary with extreme changes in thermal process. Further information is of course necessary to confirm these conjectures, but it is envisioned that eventually a formula can be predicted for any given process for determining core hardness. For the plot previously described, k = 32.5.

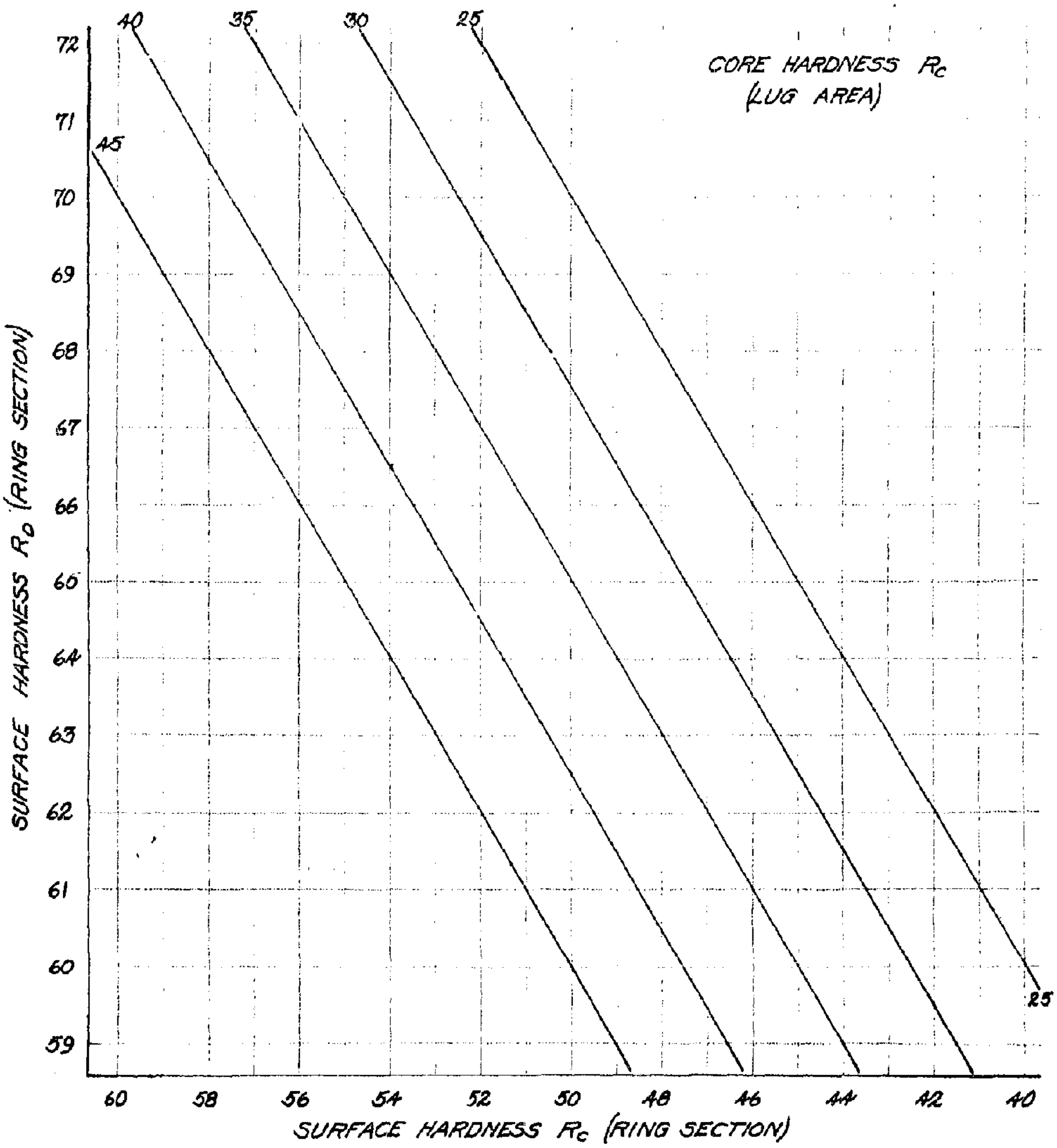
In order that further data be obtained for verification of this method, the developed chart shown in Chart 16 was used to predict the core hardness of production receivers sectioned daily and examined by the Industrial Laboratory. To date, 170 receivers fabricated from six different heat lots have been measured with a more promising correlation indicated as follows:

159 core hardness	within ± 2 Rc	- 93.5%
168	within ± 3 Rc	- 99%
170	within ± 4 Rc	- 100%

Five of the production samples found to be in error by more than two points Rockwell C were reexamined. The surface hardness was remeasured after preparing a better bearing surface for the receiver to rest on the anvil of the Rockwell machine. These second measurements predicted the core hardness on three of the pieces without error. Surface measurements on the other two were found to be accurate. However, the core hardness in the ring area directly under the position of the surface measurements was found to be five points Rockwell C different from that in the lug area. The core hardness in the ring area normally runs, due to section size, approximately two points Rockwell C lower than the core hardness in the lug area. This difference can account for a three-point Rockwell C error in prediction of the lug area core hardness. This large difference in core hardness between the two areas is probably caused by salt clinging in one area and not in the other; thus, one area is insulated to a greater degree in quenching. Figure 11 shows the manner in which salt sometimes clings to certain receiver areas.

Since this problem exists, a more accurate determination of core hardness may be obtained by measuring the surface hardness on the lug area section. A fixture is being fabricated to rigidly support the receiver for surface hardness measurements directly on the lug area. This should eliminate prediction errors resulting from variation in quench rates within a single receiver.

CHART 16 PREDICTION CHART FOR RECEIVER CORE HARDNESS



III. <u>Mechanical Hardness Tests for Core Hardness Evaluation</u> - Continued

The most important aspect of this test is the surface hardness measurement. It is emphasized that all the precautions and techniques outlined in the instruction book for the Rockwell machine must be followed. Also, both Rockwell D and C measurements must be made on the same Rockwell machine and as close to the same time as possible to cancel errors between machines, variations in penetrators, and minor loads. It is important to note further that the surface hardness readings were taken on unparkerized surfaces. It is recommended that surface hardness be measured in the unparkerized condition until the effect of parkerizing is determined.

Investigations are being continued. At this point, it is felt that a simple and accurate nondestructive method has been developed to determine core hardness. It is recommended that further data be compiled with the use of the proposed method of taking hardness directly on the lug area to verify present results. A slight correction in the prediction chart might be required because of the difference in section size between the ring and the lug areas, but a more accurate test is anticipated.

APPENDIX A

Section 1

Receiver Test Results

Initial Screening Studies

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator Amplitude	Magnetic Analysis Production Comparator Phase and Harmonics	Magnatest FS-300 Amplitude	Magnatest FS-300 Phase	Spectrographic Analysis
71244	+100	All 3rd	4.0	45	13XX
71974	+100	All 3rd	3.8	35	13XX
69121	+100+	All 3rd	4.0	50	13XX
73761	+100	90° P.S All 3rd	3.8	40	13XX
71927	+100+	90° P.S. All 3rd	3.9	40	13XX
72929	+100+	90° P.S. All 3rd	3.8	40	13XX
74238	+100+	90° P.S. All 3rd	3.7	40	13XX
74486	+100+	90° P.S All 3rd	3.8	45	13XX
66979	+100+	90° P.S. Some 3rd, 5th	4.4	70	86XX
66117	+100+	90° P.S. Some 3rd, 5th	4.5	70	86XX
71944	+95	All 3rd	4.3	65	86XX
71918	+80	All 3rd	4.3	65	86XX
69289	+75	All 3rd	4.3	70	86XX
69777	+50	All 3rd	4.3	60	86XX
71364	0	All 5th	4.9	85	86XX
71384	+15	All 5th	4.8	80	86XX
73828	+15	All 5th	4.4	75	86XX
72461	+10	All 5th	4.7	80	86XX
74166	0	All 5th	4.7	80	86XX
66628	+5	All 5th	4.9	80	86XX
73077	-40	All 5th	5.2	80	86XX
73023	-10	All 5th	5.2	85	86XX
66457	-10	Strong, 5th No, 3rd	4.6	80	86XX
66486	-35	Strong, 5th Slight 3rd	4.3	80	86XX

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator		Magnatest FS-300		Spectrographic Analysis
	Amplitude	Phase and Harmonics	Amplitude	Phase	
70040	+25	Strong 5th	4.6	80	86XX
67565	-20	Strong 5th	5.2	85	86XX
67206	+80	Some 5th	5.2	90	86XX
67529	-40	Strong 5th	5.2	80	86XX
73186	-40	Strong 5th	5.2	80	86XX
73201	-40	Strong 5th	5.2	80	86XX
73146	-60	Strong 5th	5.5	85	86XX
73227	-55	Strong 5th	5.5	85	86XX
73003	-70	Strong 5th	5.2	90	86XX
73132	-70	Strong 5th	5.2	90	86XX
73187	-50	Strong 5th	5.2	85	86XX
73191	-35	Strong 5th	5.3	90	86XX
73121	-25	Strong 5th	5.2	85	86XX
70578	-90	Strong 5th	5.2	85	86XX
68785	+5	Some 5th	4.7	80	86XX
69240	0	Slight 5th	4.7	80	86XX
68171	-80	90° P.S. Slight 5th	4.0	80	86XX
68112	-90	90° P.S Some 5th	4.5	75	86XX
73041	-50	90° P.S. Strong 5th	5.3	85	86XX
66097	-60	90° P.S. Slight	5.2	85	86XX

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator Amplitude	Phase and Harmonics	Magnatest FS-300 Amplitude	Phase	Spectrographic Analysis
66877	-40	Small P.S. Slight 5th	5.8	90	86XX
64948	-90	90° P.S.	4.7	80	86XX
73252	-60	90° P.S.	4.5	75	86XX
67292	-60	90° P.S.	4.3	70	86XX
67512	-100	90° P.S.	4.5	80	86XX
73591	-90	90° P.S.	4.3	70	86XX
73319	Off Scale -100	90° P.S.	7.0	105	86XX
73334	Off Scale -100	90° P.S.	7.1	105	86XX
71408	Off Scale -100	No P.S. No 5th	2.8	107	Not 13XX or 86XX High Nickel
72037	0	All 3rd	5.2	90	86XX
70910	-40	All 3rd	5.7	100	86XX
67750	+5	All 3rd	5.2	90	86XX
69134	0	All 3rd	5.2	85	86XX
69327	-10	All 3rd	5.2	95	86XX
68746	-10	All 3rd	5.2	85	86XX
73208	-15	All 3rd	5.2	85	86XX
71150	-10	All 3rd	5.3	90	86XX
72895	-10	All 3rd	5.2	85	86XX
65871	-15	All 3rd	5.6	90	86XX
66515	-5	All 3rd	5.0	80	86XX
66923	-30	All 3rd	5.2	85	86XX

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator		Magnatest FS-300		Spectrographic Analysis
	Amplitude	Phase and Harmonics	Amplitude	Phase	
67280	-10	All 3rd	5.5	90	86XX
67430	+20	All 3rd	5.3	85	86XX
73765	-60	All 3rd	5.7	100	86XX
67569	-30	All 3rd	5.7	95	86XX
66145	-100	90° P.S. No 5th	4.9	80	86XX

APPENDIX A

Section 2

Receiver Test Results

Test Development Studies

"Code HG" Receiver Identification	Magnetic Analysis Amplitude	Production Comparator Phase	Spectrographic Analysis
71244	+105		13XX
71974	Off Scale +100		13XX
69121	+95		13XX
73761	Off Scale +100		13XX
71927	Off Scale +100		13XX
72929	Off Scale +100		13XX
74238	Off Scale +100		13XX
74486	Off Scale +100		13XX
66979	+39	SPS	86XX
66117	+33	SPS	86XX
71944	+30		86XX
71918	+25		86XX
69289	+25		86XX
69777	+23		86XX
71364	-15		86XX
71384	+15	P. S.	86XX
73828	+5		86XX
72461	0		86XX
74166	0		86XX
66628	-8		86XX
73077	-25		86XX
73023	-14		86XX
66457	0	SPS	86XX
66486	0	SPS	86XX
70040	-2		86XX
67565	-22		86XX
67206	-11		86XX
67529	-27		86XX
73186	-20		86XX

"Code HG" Receiver Identification	Magnetic Analysis Amplitude	Production Comparator Phase	Spectrographic Analysis
73201	-20		86XX
73146	-46		86XX
73227	-48		86XX
73003	-40		86XX
73132	-38		86XX
73187	-35		86XX
73191	-32		86XX
73121	-27		86XX
70578	-50		86XX
68785	-13	SPS	86XX
69240	-12	SPS	86XX
68171	-12		86XX
68112	-22		86XX
73041	-33		86XX
66097	-30		86XX
66877	-55		86XX
64948	-10		86XX
73252	0		86XX
67292	+5		86XX
67512	-20		86XX
73591	0		86XX
73319	Off Scale -100		86XX
73334	Off Scale -105		86XX
71408	-100	Large P. S.	Not 13XX or 86XX High Nickel
72037	-30		86XX
70910	-56		86XX
67750	-16		86XX
69134	-25		86XX
69327	-35		86XX
68746	-25		86XX

"Code HG" Receiver Identification	Magnetic Analysis Amplitude	Production Comparator	Spectrographic Analysis
73208	-18		86XX
71150	-27		86XX
72895	-30		86XX
65871	-30		86XX
66515	-16		86XX
66923	-35		86XX
67280	-35		86XX
67430	-13		86XX
73765	-55		86XX
67569	-46		86XX
66145	-30		86XX

APPENDIX A

Section 3

Receiver Test Results

Correlation Studies

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator Amplitude	Phase	Magnatest FS-300 Amplitude	Spectrographic Analysis
70091	0	SPS	0	86XX
69963	0	SPS	0	86XX
70120	0	SPS	0	86XX
68788	-2	SPS	0	86XX
69570	-7	SPS	+1.5	86XX
72373	-2	SPS	+0.5	86XX
72774	0	SPS	0	86XX
69906	-5	SPS	+1.5	86XX
69995	-3	SPS	+1	86XX
69968	0	SPS	0	86XX
69923	-12	SPS	+2.5	86XX
70077	-5	SPS	+0.5	86XX
70076	-10	SPS	+1.5	86XX
70054	0	SPS	0	86XX
70093	+2	SPS	-1	86XX
69896	0		-1	86XX
69902	-8	SPS	+1.5	86XX
69924	-4		0	86XX
69727	+8	SPS	-2.5	86XX
69779	+12	SPS	-2.5	86XX
69785	+19	SPS	-3.5	86XX
69787	+2	SPS	-1	86XX
69793	+13	SPS	-3	86XX
69801	0	SPS	-1	86XX
69804	0	SPS	-1	86XX
69825	-6		+1	86XX
69114	-3		0	86XX
69773	+20	SPS	-3.5	86XX
72062	+1	SPS	-1	86XX

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator Amplitude	Phase	Magnatest FS-300 Amplitude	Spectrographic Analysis
68453	-7	SPS	+1	86XX
68541	-9	SPS	+1.5	86XX
73848	+23	SPS	-3.5	86XX
71672	+26	SPS	-4	86XX
68079	+2	SPS	-1	86XX
69965	-5		+1.5	86XX
72013	+40	SPS	-5.5	86XX
73251	-4	SPS	0	86XX
74167	+40	SPS	-4.5	86XX
73088	-20		+3.5	86XX
71298	-6		+1.5	86XX
72790	-52	SPS	+7	86XX
71994	+39	SPS	-4.5	86XX
72468	-22		+4	86XX
69069	+20	SPS	-2.5	86XX
73084	Off Scale -100	SPS	Off Scale +	86XX
74493	+60		-6.5	86XX
69967	Off Scale -100	SPS	Off Scale +	86XX
67039	+45		-5	86XX
71984	Off Scale -100	SPS	Off Scale +	86XX
69154	-17	SPS	+2.5	86XX
72382	0	SPS	0	86XX
73031	-30	SPS	+4	86XX
67196	-10		+1.5	86XX
67906	-24	SPS	+3	86XX
68254	-2	SPS	0	86XX
67456	-5	SPS	+1	86XX
74031	+11	SPS	-2.5	86XX

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator Amplitude	Phase	Magnatest FS-300 Amplitude	Spectrographic Analysis
67461	0	SPS	0	86XX
67241	-5	SPS	0	86XX
71167	-6	SPS	+1.5	86XX
67326	-23		+3.5	86XX
68069	-6	SPS	+1	86XX
67754	+2		-0.5	86XX
67970	-7	SPS	+1	86XX
68257	-17	SPS	+2	86XX
68233	-5	SPS	0	86XX
68360	+5	SPS	-1	86XX
66250	+4	SPS	-1.5	86XX
66642	-8	SPS	+1.5	86XX
66454	-15	SPS	+2.5	86XX
66666	0	SPS	-0.5	86XX
66495	+7	SPS	-1.5	86XX
68113	+4	SPS	-1.5	86XX
68320	-6		+1	86XX
67425	-11		+1.5	86XX
69339	-16		+2	86XX
65867	+2	SPS	-1	86XX
73797	0	SPS	-1	86XX
70490	+2	SPS	0	86XX
73612	+4	SPS	+1	86XX
68816	-2	SPS	+1	86XX
66070	-32		+4	86XX
68627	-10		+2.5	86XX
72994	-40	SPS	+6	86XX
71687	+15	SPS	-2.5	86XX

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator Amplitude	Phase	Magnatest FS-300 Amplitude	Spectrographic Analysis
68625	-12	SPS	+2	86XX
72982	0		0	86XX
69969	-5	SPS	+1.5	86XX
71937	+7		-1.5	86XX
68952	-2	SPS	0	86XX
70707	-2	SPS	+1.5	86XX
70710	-5		+1	86XX
70646	-2		+0.5	86XX
70643	0		0	86XX
70634	-6	SPS	+1	86XX
70828	-6	SPS	+1	86XX
70807	-1	SPS	0	86XX
70793	-2	SPS	0	86XX
70689	-2		0	86XX
70783	+2	SPS	-1	86XX
70778	0	SPS	-1	86XX
70666	-2	SPS	0	86XX
70662	0		+0.5	86XX
70733	0	SPS	-0.5	86XX
70653	-12	SPS	+2	86XX
67884	+10	SPS	-2.5	86XX
67287	-2		0	86XX
67230	-3		+1	86XX
73209	-16		+3	86XX
70583	-2		+1	86XX
72974	0		0	86XX
71900	+3		0	86XX
71802	+30		-3.5	86XX
73948	+23	SPS	-4	86XX

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator Amplitude	Phase	Magnatest FS-300 Amplitude	Spectrographic Analysis
73796	+3		-1	86XX
73347	+16		-2.5	86XX
68287	-2		+1	86XX
74359	+18	SPS	-3.5	86XX
73966	+2		-0.5	86XX
73538	-26		+4.5	86XX
68174	-2	SPS	+1	86XX
68376	-8	SPS	+2	86XX
67251	-10	SPS	+1.5	86XX
69416	+12	SPS	-2.5	86XX
67403	-2		+0.5	86XX
73768	-13		+2.5	86XX
70363	-5	SPS	+1.5	86XX
68225	-5		+1.5	86XX
68845	-2		+1	86XX
68846	-3		+1	86XX
69256	-2		+1.5	86XX
69270	-18	SPS	+3.5	86XX
69575	-2	SPS	+1.5	86XX
68261	0	SPS	0	86XX
67485	-7	SPS	+1.5	86XX
71848	+14		-2.5	86XX
70081	-1	SPS	0	86XX
71004	-9	SPS	+1	86XX
71309	-3		0	86XX
73644	0	SPS	0	86XX
74254	+5		-1	86XX
72673	-10		+1.5	86XX
71916	+30		-4	86XX
67647	+4		-1	86XX

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator Amplitude	Phase	Magnatest FS-300 Amplitude	Spectrographic Analysis
70706	-14		+1.5	86XX
69828	0		-1	86XX
69829	-3		0	86XX
69842	-2		0	86XX
69861	-1		0	86XX
69866	-2		+1	86XX
71037	0	SPS	-0.5	86XX
68941	+2		-0.5	86XX
69182	0		0	86XX
66874	-13		+2.5	86XX
68700	0	SPS	0	86XX
68329	+1	SPS	-0.5	86XX
70069	-10	SPS	+1.5	86XX
65637	-2		+0.5	86XX
69537	-3	SPS	+0.5	86XX
69173	+3		-0.5	86XX
70800	-2		0	86XX
70587	-10	SPS	+1.5	86XX
69690	+2	SPS	-1	86XX
68205	+1	SPS	-0.5	86XX
68911	-2		0	86XX
70836	-1		0	86XX
70842	+2		-1	86XX
70847	0		0	86XX
70867	-12	SPS	+2	86XX
70869	-8	SPS	+1.5	86XX
70881	+4	SPS	-1.5	86XX
70896	-6	SPS	0	86XX
70898	+2	SPS	-1.5	86XX

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator Amplitude	Phase	Magnatest FS-300 Amplitude	Spectrographic Analysis
70899	-4	SPS	0	86XX
70912	-7	SPS	+1	86XX
70932	-1		0	86XX
70936	+5	SPS	-1.5	86XX
71003	-4	SPS	0	86XX
71031	+1	SPS	-1	86XX
71025	+4	SPS	-1.5	86XX
74273	0	SPS	-1	86XX
66286	-4	SPS	0	86XX
72465	-30		+4	86XX
66247	+4		-1.5	86XX
65957	-30	SPS	+4	86XX
66463	+3	SPS	-1.5	86XX
66867	-12	SPS	+1.5	86XX
67213	-1		0	86XX
67142	-5	SPS	0	86XX
74244	-2	SPS	-1	86XX
70952	+7	SPS	-2	86XX
71921	+4	SPS	-1.5	86XX
74308	-2	SPS	0	86XX
73860	+2	SPS	-1.5	86XX
69380	-4	SPS	0	86XX
68732	-5		+1.5	86XX
69190	-5	SPS	+1.5	86XX
69230	-2	SPS	0	86XX
69282	+2	SPS	0	86XX
69296	+7	SPS	-1.5	86XX
69300	+2	SPS	0	86XX
69557	-9	SPS	+1	86XX
68706	-7		+1.5	86XX

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator		Magnatest FS-300	Spectrographic Analysis
	Amplitude	Phase	Amplitude	
68794	+2		0	86XX
68649	-18	SPS	+3	86XX
68834	0	SPS	-0.5	86XX
68910	-10	SPS	+2	86XX
68949	-5	SPS	+1	86XX
68979	-4	SPS	+1	86XX
69081	+6		-1	86XX
70892	-6	SPS	+1.5	86XX
70574	-2		+0.5	86XX
70883	+2	SPS	-1	86XX
70922	-2		+0.5	86XX
70927	-3		+0.5	86XX
70750	-5		+1.5	86XX
67479	-17	SPS	+3	86XX
70591	-5	SPS	+1.5	86XX
70066	-12	SPS	+2.5	86XX
70145	-11	SPS	+2.5	86XX
70295	-8	SPS	+2	86XX
72007	0	SPS	+0.5	86XX
68970	+2	SPS	+0.5	86XX
71161	+2	PS	0	86XX
70476	-12	SPS	+2.5	86XX
70613	-12	SPS	+2.5	86XX
70614	0		0	86XX
70620	-17	SPS	+3	86XX
70625	-10		+2	86XX
70632	-10	SPS	+2	86XX
70495	-8	SPS	+1.5	86XX
70470	-4		+1	86XX
70415	0	SPS	0	86XX

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator Amplitude	Magnetic Analysis Production Comparator Phase	Magnatest FS-300 Amplitude	Spectrographic Analysis
70411	-4	SPS	+1	86XX
70401	0	SPS	0	86XX
70399	-11	SPS	+2	86XX
70347	-13	SPS	+2.5	86XX
70570	-14	SPS	+2.5	86XX
70585	-5	SPS	+1.5	86XX
70599	-6	SPS	+1.5	86XX
71506	-6	SPS	+1.5	86XX
72010	+4		-0.5	86XX
71550	-10	SPS	+2	86XX
71864	+15	SPS	-2	86XX
71928	+9	SPS	-1.5	86XX
71042	+5	SPS	-1	86XX
71064	0	SPS	0	86XX
71075	+2		0	86XX
71337	-6		+1	86XX
71386	-10	SPS	+2	86XX
71437	-3	SPS	+1	86XX
71453	-5		+1.5	86XX
71486	0	SPS	0	86XX
71500	-7	SPS	+1.5	86XX
71504	0	SPS	0	86XX
73505	+3		0	86XX
69427	-15		+3.5	86XX
71235	Off Scale +100		-14	13XX
70575	-7		+2	86XX
68020	+10		-1	86XX
70698	+95		-10	13XX
74062	+5		0	86XX
68994	0		+1	86XX

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator Amplitude	Phase	Magnatest FS-300 Amplitude	Spectrographic Analysis
73852	+15		-2	86XX
67617	0		+1	86XX
68383	-20	PS	+3	86XX
68679	-12		+2.5	86XX
74312	-12		+2.5	86XX
71180	+5		0	86XX
66762	-15		+3.5	86XX
68849	+2	SPS	-1	86XX
69890	-2	SPS	0	86XX
69605	+5	SPS	-1.5	86XX
69272	+4	SPS	-1.5	86XX
69571	0	SPS	-1	86XX
69321	0	SPS	-1	86XX
70966	+20		-3	86XX
70055	-10		+1.5	86XX
67008	+23		-3.5	86XX
70413	-7	SPS	0	86XX
67885	-10	SPS	+1	86XX
68907	-6	SPS	+1	86XX
68874	+2	SPS	-1.5	86XX
67362	-11		+2	86XX
70420	-6	SPS	+1	86XX
72364	+3		-1	86XX
71583	+36		-4.5	86XX
74032	+30	SPS	-4.5	86XX
74492	+20		-3	86XX
72351	+16	SPS	-3.5	86XX
74182	-2		0	86XX
71361	+2		0	86XX

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator Amplitude	Magnetic Analysis Production Comparator Phase	Magnatest FS-300 Amplitude	Spectrographic Analysis
71887	-3		+1	86XX
72156	+8		-1.5	86XX
70110	-6		+1	86XX
67613	-7		+2.5	86XX
67854	-2		+1	86XX
72933	-33		+5	86XX
70039	+2		-1	86XX
68380	-26		+4	86XX
70529	-15	SPS	+2	86XX
70555	0		0	86XX
70316	0	SPS	0	86XX
70305	-2		0	86XX
70292	-3	SPS	0	86XX
70283	0		0	86XX
70261	-6		+1	86XX
70215	0		0	86XX
70161	-2	SPS	0	86XX
70196	-7	SPS	+1	86XX
70180	0	SPS	-1	86XX
70172	0	SPS	-1	86XX
70152	0		0	86XX
70135	-2		0	86XX
70137	0		0	86XX
69268	-24	SPS	+3.5	86XX
71606	+3	SPS	-1.5	86XX
69899	-13		+1.5	86XX
69606	-6		+1	86XX
66270	+22	SPS	-3.5	86XX
68944	-16		+2.5	86XX
68001	-22	SPS	+3	86XX
69986	-8	SPS	+1.5	86XX

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator Amplitude	Phase	Magnatest FS-300 Amplitude	Spectrographic Analysis
71710	+11	SPS	-2.5	86XX
69322	-57	SPS	+7	86XX
69504	-20	SPS	+3	86XX
68780	-12	SPS	+2	86XX
67377	-2	SPS	0	86XX
71287	-6	SPS	+1	86XX
71586	+17	SPS	-3	86XX
69318	-4	SPS	+15	86XX
69028	-8	SPS	+2	86XX
69246	-2	SPS	+1	86XX
69320	+3	SPS	0	86XX
69030	0	SPS	0	86XX
69125	-3	SPS	+1	86XX
69131	-4		+1	86XX
68571	-5		+1	86XX
69316	-7	SPS	+1.5	86XX
67558	-18		+2.5	86XX
66809	+4	SPS	-2	86XX
66572	-10		+1.5	86XX
68543	0	SPS	0	86XX
68352	+2	SPS	1	86XX
67737	-6	SPS	+1.5	86XX
68638	-9	SPS	+1	86XX
69442	-3		0	86XX
69429	-8	SPS	+1	86XX
68043	-8	SPS	+1	86XX
71316	-5	SPS	+1	86XX
69452	0	SPS	0	86XX
66746	+9	SPS	-2	86XX

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator Amplitude	Phase	Magnatest FS-300 Amplitude	Spectrographic Analysis
67112	+10	SPS	-2.5	86XX
66961	-16	SPS	+2	86XX
67183	-10	SPS	+1.5	86XX
68915	+5	SPS	-2	86XX
68572	-12	SPS	+2	86XX
68533	-2	SPS	0	86XX
67413	-2		0	86XX
68962	0	SPS	0	86XX
69505	-2		+1.5	86XX
69331	-33	SPS	+5	86XX
71988	+18		-2.5	86XX
73886	+25		-3	86XX
71654	+28	PS	-4	86XX
71034	+25	SPS	-2.5	86XX
73178	-25		+4.5	86XX
67707	+43	PS	-5.5	86XX
73009	+4		-1	86XX
73052	+3		0	86XX
69047	-32	SPS	5	86XX
71380	+2	SPS	0	86XX
74489	+20		-2.5	86XX
71718	+18		-2	86XX
73574	-3		+1.5	86XX
66871	-32	SPS	+4.5	86XX
70416	-32	SPS	+4	86XX
70087	-3	SPS	0	86XX
66340	+10	SPS	-1.5	86XX
73111	-35	SPS	+4.5	86XX
73952	+12	SPS	-2.5	86XX
73124	-36	SPS	+4.5	86XX

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator Amplitude	Phase	Magnatest FS-300 Amplitude	Spectrographic Analysis
69507	-28	SPS	+3.5	86XX
68258	+2	SPS	-1	86XX
68252	-6		+1	86XX
67299	-2	SPS	-1	86XX
71970	+28	SPS	-4	86XX
71844	+20	SPS	-3.5	86XX
72397	+5	SPS	-1.5	86XX
73094	-12		+2	86XX
73660	-13	SPS	+1.5	86XX
73915	-8	SPS	+2	86XX
68861	-10	SPS	+1.5	86XX
72947	-39	SPS	+5	86XX
68223	-3	SPS	0	86XX
67451	-5		+1	86XX
66638	-11		+1	86XX
73743	-2	SPS	0	86XX
67262	-12	SPS	+2	86XX
69392	-36	PS	+4	86XX
69020	-18	SPS	+2.5	86XX
72682	-1		0	86XX
69467	-25	SPS	+3.5	86XX
67426	-8		+1.5	86XX
67788	-20	PS	+3	86XX
67278	-2	SPS	0	86XX
70664	-13		+2	86XX
71219	-15	SPS	+2	86XX
68815	+8	SPS	-1.5	86XX
68632	-5	SPS	0	86XX
70050	0	PS	-1	86XX

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator Amplitude	Phase	Magnatest FS-300 Amplitude	Spectrographic Analysis
70787	-10	SPS	+1.5	86XX
69029	-3	SPS	0	86XX
70645	-13	SPS	+2	86XX
69314	+8	SPS	-2.5	86XX
69274	+4	SPS	-2	86XX
71310	-16	SPS	+2	86XX
69381	0	SPS	0	86XX
68825	0	SPS	0	86XX
67993	-7	SPS	+1	86XX
69478	0		0	86XX
71204	-15	SPS	+2	86XX
69692	+11	SPS	-2.5	86XX
68496	-6	SPS	+1	86XX
68497	-2		0	86XX
68524	-8	SPS	+1	86XX
68619	0	SPS	0	86XX
71441	-3	SPS	0	86XX
68530	+3	SPS	-1	86XX
68483	+2	SPS	-1	86XX
68415	+2	SPS	-1	86XX
70684	-10		+1.5	86XX
70897	+2	SPS	-1.5	86XX
71015	-6	SPS	+0.5	86XX
71211	-8	SPS	+1	86XX
68950	-3	SPS	0	86XX
69138	-3	SPS	0	86XX
69136	-2		0	86XX
69139	-6		+1	86XX
69140	+2		-1	86XX
72058	+16		-3	86XX
71549	0		-0.5	86XX

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator Amplitude	Phase	Magnatest FS-300 Amplitude	Spectrographic Analysis
72043	+4		-1.5	86XX
72009	+9		-2.5	86XX
69024	-4	SPS	0	86XX
69005	+2	SPS	-1	86XX
69000	-1	SPS	0	86XX
69552	-5	SPS	+1	86XX
69455	-8	SPS	+1	86XX
69317	-12	SPS	+2	86XX
69275	-5	SPS	+1.5	86XX
69251	-30	SPS	+4.5	86XX
70014	-18	SPS	+2.5	86XX
73927	+2	SPS	-0.5	86XX
68479	-16	SPS	+2.5	86XX
69652	-37	SPS	+5.5	86XX
66549	-3		0	86XX
66656	-12		+2.5	86XX
66862	-18		+2.5	86XX
67918	0	SPS	0	86XX
67856	-11		+2	86XX
66948	+14	SPS	-2.5	86XX
66163	-3	SPS	+1	86XX
65870	+7		-1	86XX
66803	-6		+1.5	86XX
70303	-16	SPS	+2	86XX
70053	+10		-1.5	86XX
70112	-1	SPS	-1	86XX
70041	+1	SPS	-1	86XX
70061	-8	SPS	+1.5	86XX
69242	-2	SPS	0	86XX
68296	-5	SPS	+1	86XX
68715	-3		0	86XX
70716	-5	SPS	0	86XX
70686	-10		+1	86XX
67432	-8		+1.5	86XX

"Code HG" Receiver Identification	Magnetic Analysis Production Comparator		Magnatest FS-300	Spectrographic Analysis
	Amplitude	Phase	Amplitude	
69985	-5		0	86XX
69863	-5	SPS	+0.5	86XX
69818	0	SPS	-0.5	86XX
69999	-6	SPS	0	86XX
69484	-11	SPS	+1.5	86XX
69593	-3	SPS	0	86XX
69512	-2		0	86XX
67380	-24	SPS	+3.5	86XX

Figures 1 to 11

FIGURE 1

SPRINGFIELD ARMORY - ORDNANCE CORPS

Neg: 19-058-1397/ORD-60 Date: 15 Dec 1960 Proj:

RIFLE, 7.62-MM, M14 - "Code WH" #19478

DAMAGED RECEIVER

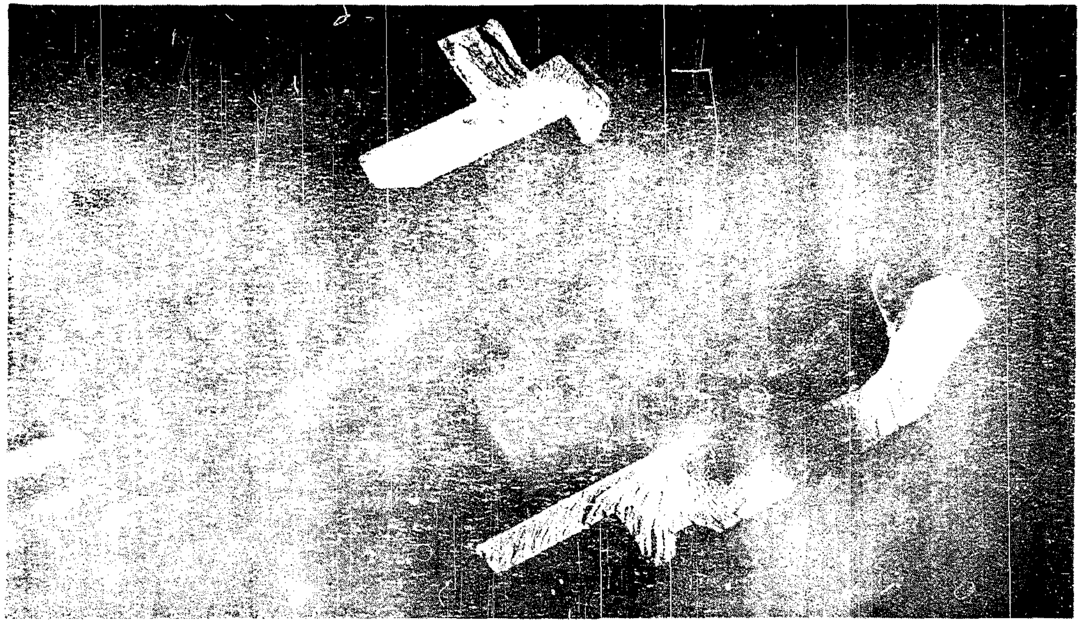


FIGURE 2

SPRINGFIELD ARMORY - ORDNANCE CORPS

Neg: 19-058-1396/ORD-60 **Date:** 15 Dec 1960 **Proj:**

RIFLE, 7.62-MM, M14 - "Code WH" #19473

RECEIVER

Showing Fracture Sections

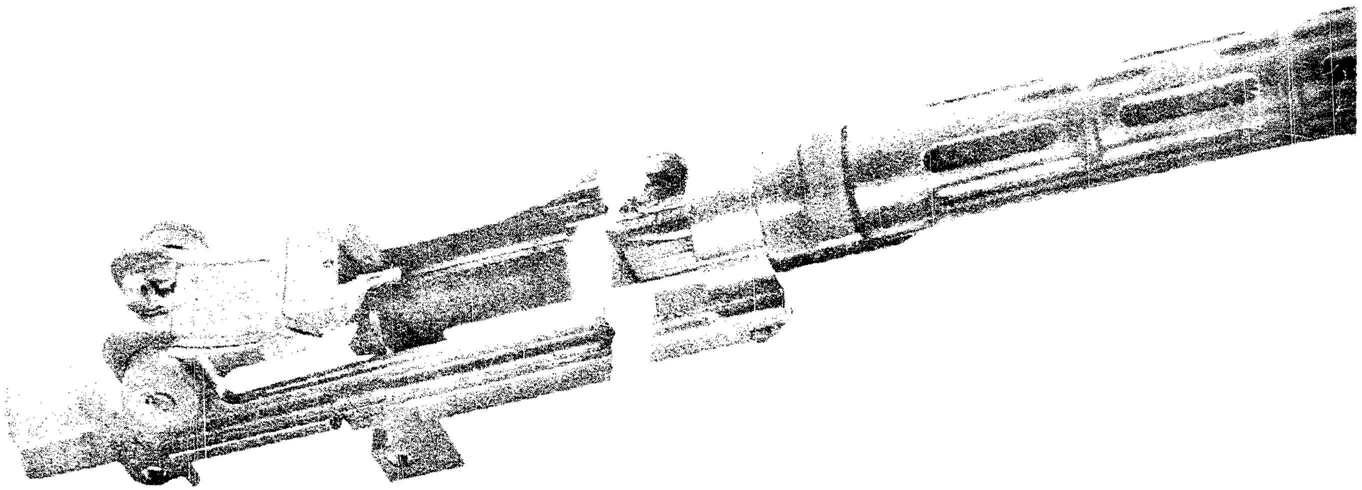


FIGURE 3

SPRINGFIELD ARMORY - ORDNANCE CORPS

Neg: 19-058-1386/ORD-60 Date: 20 Dec 1960 Proj:

RIFLE, 7.62-MM, M14 - "Code HG" #73293

DAMAGED RECEIVER

After Firing One Proof Round

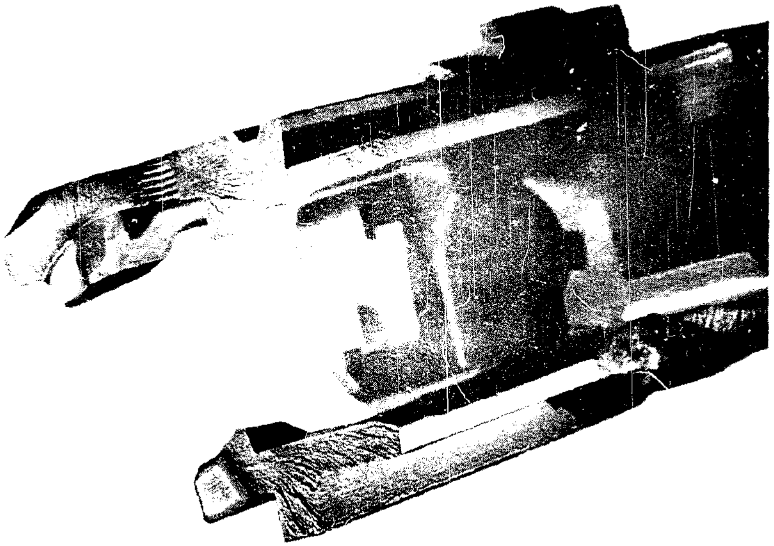


FIGURE 4

SPRINGFIELD ARMORY - ORDNANCE CORPS

Neg: 19-058-1388/ORD-60 **Date:** 20 Dec 1960 **Proj:**

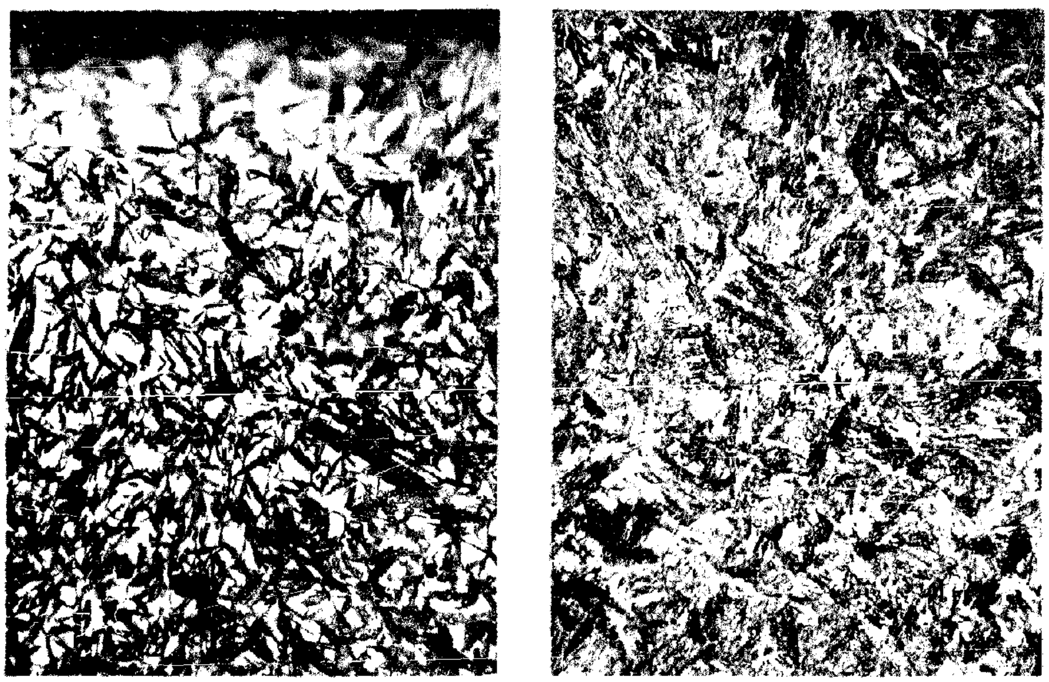
RIFLE, 7.62-MM, M14 - "Code HG" #73293

RECEIVER FRACTURE

After Firing One Proof Round

FIGURE 5 - PHOTOMICROGRAPH - STRUCTURE "CODE HC" RECEIVER 73293

CASE CORE



ETCHANT: NITAL MAG.: 1000 X

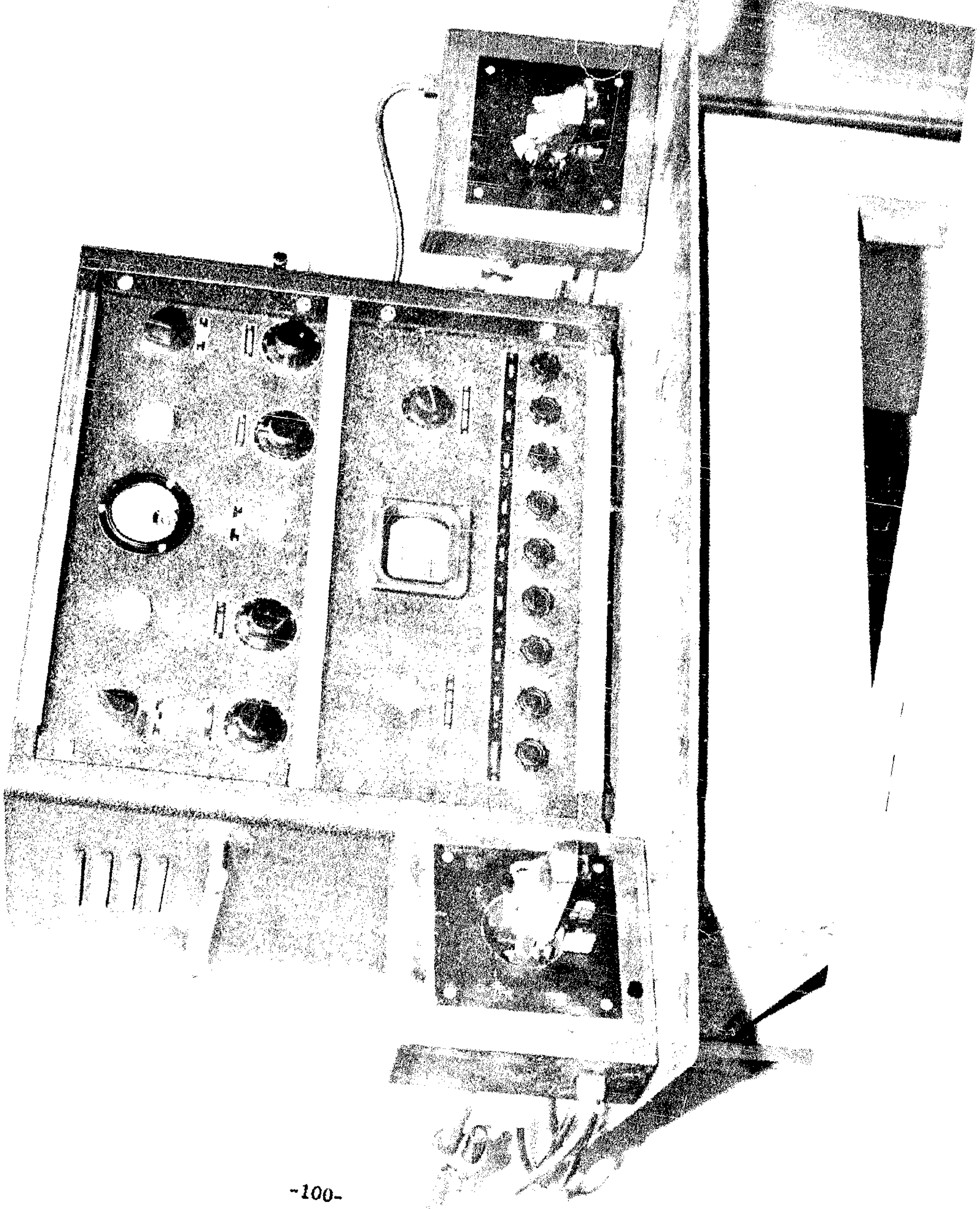
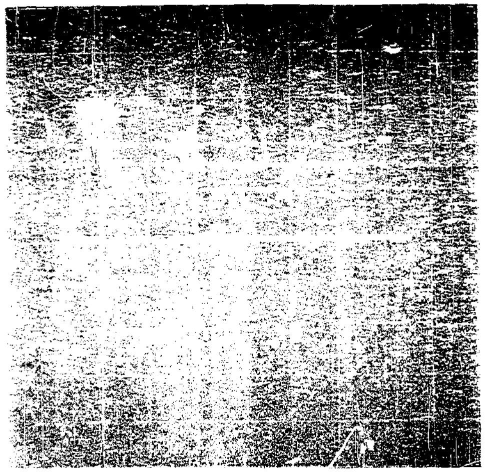


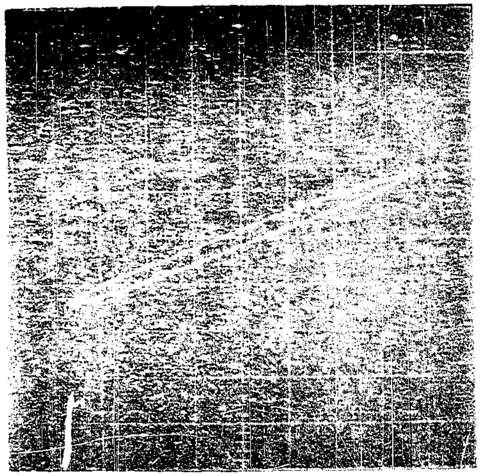
FIGURE 7 - EQUIPMENT METER READINGS AND SCOPE PATTERNS

8620 H MATERIAL RECEIVER



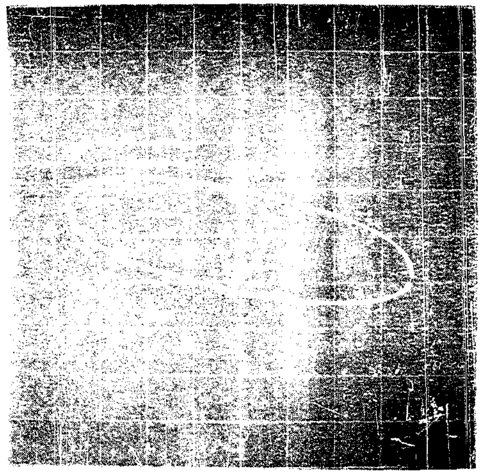
METER READING 0

1330 MATERIAL RECEIVER



METER READING +100

HIGH NICKEL MATERIAL RECEIVER



METER READING -100

FIGURE 8 - AREAS - CORE HARDNESS MEASUREMENTS

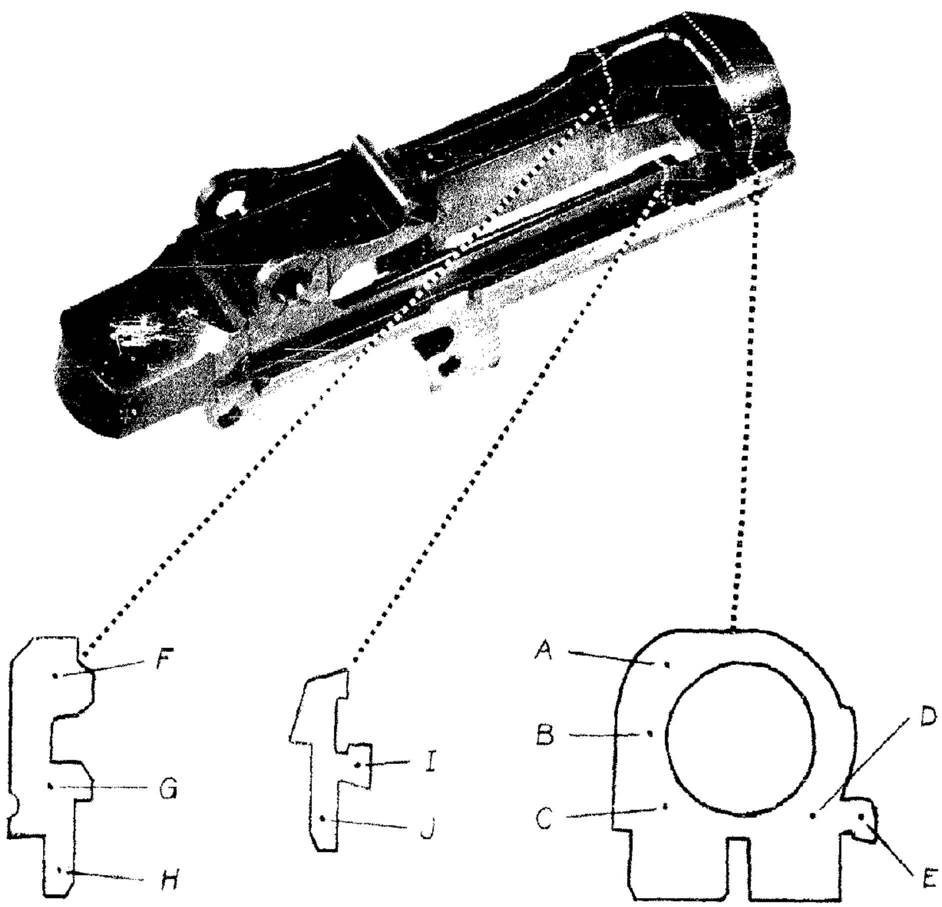
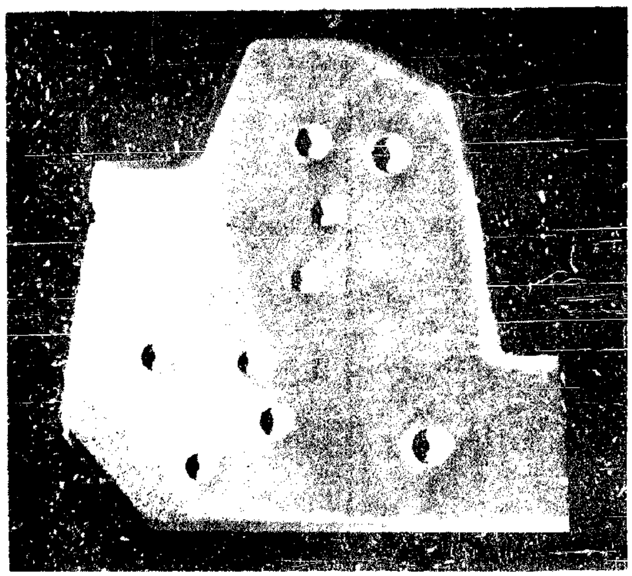


FIGURE 9 - MACROGRAPH SHOWING LOCALLY ANNEALED SECTION IN "CODE HG" RECEIVER NO. 71980



Etchant: Nital. Magnification: 6X.

FIGURE 10 CIRCUIT FOR THIRD HARMONIC AMPLITUDE MEASUREMENTS

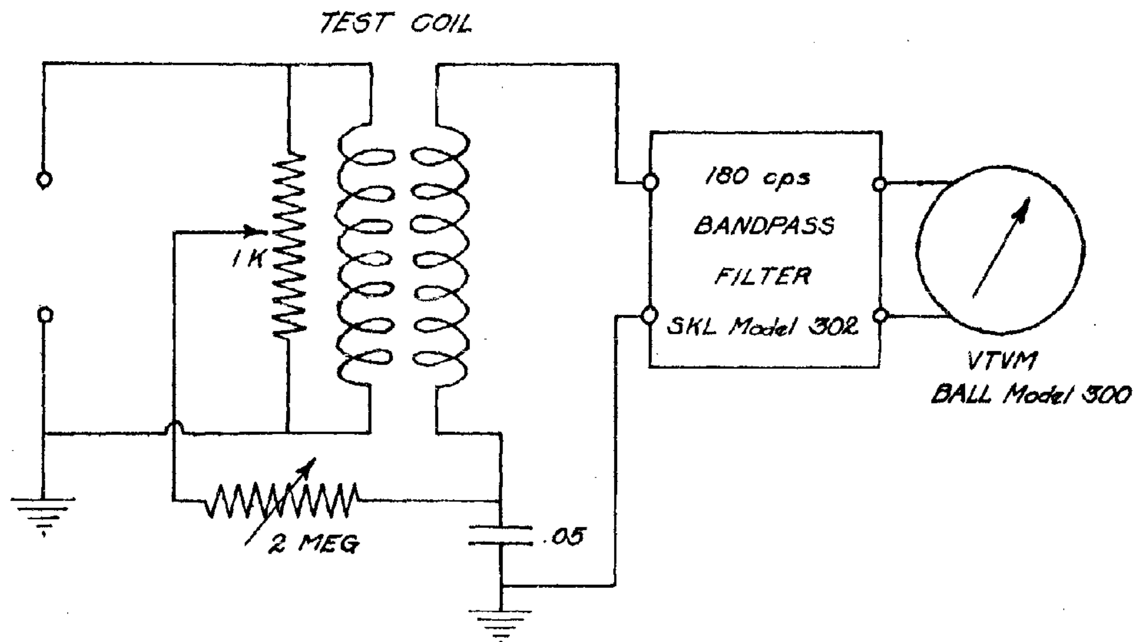
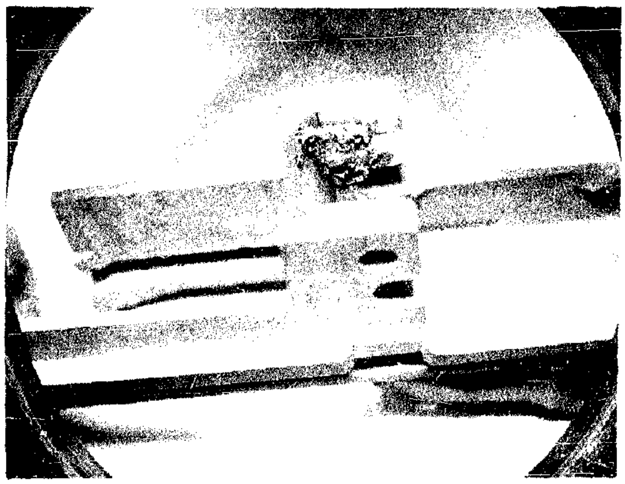


FIGURE 11 MANNER IN WHICH SALT CLINGS TO CERTAIN RECEIVER SECTIONS



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PROPERTIES AND METHODS OF NONDESTRUCTIVE TESTING OF RECEIVERS FOR THE 7.62MM M14 RIFLE, by R. D. Korytoski, H. P. Hatch, and E. H. Abbe, Technical Report SA-TR19-1506, 7 Nov 61, 110 pp incl illus, Ord Proj - Industrial Preparedness Measure.

UNCLASSIFIED REPORT

Limited distribution due to coding.

Studies were made to develop a nondestructive test for the segregating of receivers made from materials other than the specified resulphurized 8620H steel, and to determine the feasibility of using the electromagnetic test for this segregation. The electromagnetic comparison test gave 100 per cent correlation with spectrographic analysis results of 554 receivers. The developed method did not correlate completely with core properties in the receiver lug areas. The results obtained by this method are influenced by variations in the heat-treat procedures. It was recommended that the electromagnetic method be used in conjunction with core hardness predictions by Rockwell C and D measurements at designated locations. Test procedures are described.

1. Nondestructive testing
2. Electromagnetic test methods
3. Receiver, M14, 7.62mm

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